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# A Reference Handbook

OF

# THE MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

## SCIENTIFIC AND PRACTICAL MEDICINE

AND

## ALLIED SCIENCE

*BY VARIOUS WRITERS*

FIRST AND SECOND EDITIONS EDITED BY
ALBERT H. BUCK, M. D.

## THIRD EDITION

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VOLUME THREE

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# LIST OF CONTRIBUTORS TO VOLUME III.

ISAAC ADLER, M.D., ..... NEW YORK.
Consulting Physician New York Polyclinic, German, Beth Israel and Peoples' Hospitals and Montefiore Home.

CHARLES LEWIS ALLEN, M.D., LOS ANGELES, CAL.
Assistant Professor and Chief of the Neurological Clinic, Los Angeles Department, College of Medicine, University of California; Neurologist to the County and Children's Hospitals.

JAMES RAE ARNEILL, M.D., .... DENVER, COLO.
Professor of Medicine, University of Colorado; Physician to St. Joseph's and St. Luke's Hospitals.

LEONARD W. BACON, M.D., .. NEW HAVEN, CONN.
Instructor in Operative Surgery, Medical Department, Yale University.

JAMES B. BAIRD, M.D., ..... ATLANTA, GA.
Formerly Professor of Clinical Medicine, Southern Medical College; Attending Physician, Grady Hospital.

FRANK BAKER, M.D., PH.D., .. WASHINGTON, D. C.
Professor of Anatomy, Georgetown University School of Medicine; Supt., National Zoological Park, Smithsonian Institution.

EDGAR GARRISON BALLENGER, M.D., ATLANTA, GA.
Lecturer in Genito-urinary Diseases, Atlanta School of Medicine; Editor of the Atlanta Journal Record of Medicine; Member of the Staff of the Presbyterian Hospital.

CHARLES J. BARTLETT, M.D., NEW HAVEN, CONN.
Professor of Pathology, Medical Department, Yale University.

A. L. BENEDICT, M.D., ..... BUFFALO, N. Y.
Editor of the Buffalo Medical Journal; Consultant in Digestive Diseases, City and Columbus Hospitals; Attending Physician, Mercy Hospital.

HENRY W. BERG, M.D., ..... NEW YORK.
Associate in Pediatrics, College of Physicians and Surgeons, Columbia University; Attending Physician, Willard Parker Hospital; Associate Physician, Mt. Sinai Hospital.

ROBERT PAYNE BIGELOW, PH.D., BOSTON, MASS.
Assistant Professor of Zoology and Parasitology, Massachusetts Institute of Technology.

NELSON M. BLACK, M.D., .... MILWAUKEE, WIS.
Oculist and Aurist to Northwestern Branch, National Home for Disabled Volunteer Soldiers.

ALBERT H. BUCK, M.D., ..... NEW YORK.
Editor, First and Second Editions, REFERENCE HANDBOOK.

L. DUNCAN BULKLEY, A.B., A.M., M.D., NEW YORK.
Attending Physician, New York Skin and Cancer Hospital; Consulting Dermatologist, Randall's Island Hospital; Consulting Physician, New York Hospital; Consulting Dermatologist, Ruptured and Crippled and Manhattan Eye and Ear Hospitals.

HUGH CABOT, M.D., ..... BOSTON, MASS.
Surgeon to Out-patients, Massachusetts General Hospital; Attending Surgeon, Baptist Hospital.

C. N. B. CAMAC, M.D., ..... NEW YORK.
Assistant Professor of Clinical Medicine, College of Physicians and Surgeons, Columbia University; Physician to New York City Hospital; Formerly Professor of Clinical Medicine, Cornell University Medical College in New York City.

WILLIAM S. CARTER, M.D., GALVESTON, TEXAS.
Professor of Physiology and Hygiene and Dean of the Medical Faculty of the University of Texas.

MARGARET A. CLEAVES, M.D., ..... NEW YORK.

SOLOMON SOLIS COHEN, A.B., A.M., M.D., PHILADELPHIA, PA.
Professor of Clinical Medicine, Jefferson Medical College; Physician to the Philadelphia General, Jefferson, Rush and Jewish Hospitals.

W. J. CONKLIN, M.D., ..... DAYTON, OHIO.
Consulting Physician to St. Elizabeth's and Miami Valley Hospitals.

WILLIAM H. CRISP, M.D., ..... DENVER, COLO.
Assistant Editor, Ophthalmic Literature.

ANDREW F. CURRIER, M.D., MT. VERNON, N. Y.
Consulting Gynecologist McDonough Memorial, Ossining and Mt. Vernon Hospitals.

CHARLES T. DADE, M.D., ..... NEW YORK.
Consulting Dermatologist, Roosevelt Hospital and Englewood Hospital, N. J.; Vassar Brothers' Hospital, Poughkeepsie, N. Y.; Dermatologist, St. Luke's Hospital Clinic.

CHARLES L. DANA, A.B., A.M., M.D., NEW YORK.
Professor of Nervous Diseases, Bellevue Hospital Medical College and Cornell Medical College; Physician to Bellevue Hospital.

NATHAN S. DAVIS, M.D., ..... CHICAGO, ILL.
Professor of the Principles and Practice of Medicine, Northwestern University; Physician to Mercy, Wesley, and St. Luke's Hospitals.

GEORGE V. N. DEARBORN, A.M., M.D., PH.D., BOSTON, MASS.
Professor of Physiology, Tufts Medical and Dental Schools, Boston; Professor of the Philosophy of Physical Education, Sargent Normal School, Cambridge.

D. BRYSON DELAVAN, A.B., M.D., .... NEW YORK.
Surgeon and Professor of Laryngology, New York Polyclinic Medical School and Hospital; Consultant St. Luke's, Mt. Sinai, General Memorial Hospitals and Hospital for Ruptured and Crippled, New York, Vassar Brothers' Hospital, Poughkeepsie, and Stony Wold Sanatorium.

GEORGE DOCK, M.D., A.M., SC.D., ST. LOUIS, MO.
Professor of Medicine, Washington University Medical School; Investigator in Pathology and Clinical Medicine.

HENRY H. DONALDSON, A.B., PH.D., D.SC., PHILADELPHIA, PA.
Professor of Neurology, Wistar Institute of Anatomy and Biology.

W. A. NEWMAN DORLAND, A.B., A.M., M.D., CHICAGO, ILL.
Professor of Obstetrics, Loyola University, Chicago.

ALVAH H. DOTY, M.D.,.....NEW YORK.
Lecturer on Quarantine Sanitation, University and Bellevue Hospital Medical College; Medical Director, Employees' Benefit Fund Committee, Western Union Telegraph Company.

EDWARD K. DUNHAM, PH.B., M.D., NEW YORK.
Formerly Professor of Pathology, University and Bellevue Medical College.

CARROLL E. EDSON, M.D.,.....DENVER, COLO.

GEORGE T. ELLIOTT, M.D.,.....NEW YORK.
Consulting Dermatologist, St. Luke's and Lying-in Hospitals and New York State Hospital for Crippled Children; Consulting Physician, New York Eye and Ear Infirmary and Skin and Cancer Hospitals.

DUNCAN EVE, B.S., A.M., M.D., NASHVILLE, TENN.
Professor of Surgery and Clinical Surgery, Vanderbilt University; Consulting Surgeon, Nashville City Hospital.

EDWIN ALLEN FAY, A.B., A.M., PH.D., WASHINGTON, D. C.
Professor and Vice-president, Gallaudet College; Editor, American Annals of the Deaf.

ALFRED GORDON, M.D.,.....PHILADELPHIA, PA.
Neurologist Mt. Sinai, Northwestern General and Douglas Memorial Hospitals.

JOHN GREEN, A.B., S.B., A.M., M.D., LL.D., ST. LOUIS, MO.
Professor of Ophthalmology, St. Louis Medical College, Washington University.

JAMES S. GREENE, M.D.,....JERSEY CITY, N. J.
Surgeon to the Eye, Ear, Nose and Throat Department, German Hospital.

WINFIELD S. HALL, B.S., M.D., M.S., PH.D., CHICAGO, ILL.
Professor of Physiology, Northwestern University Medical School; Lecturer on Physiology, Institute and Training School of Y. M. C. A. and Lecturer on Dietetics, Wesley Hospital School for Nurses.

ALLEN McLANE HAMILTON, M.D., NEW YORK.

W. A. HARDAWAY, M.D.,.....ST. LOUIS, MO.
Honorary Member of the American Dermatological Association.

T. STUART HART, A.M., M.D.,.....NEW YORK.
Associate in Medicine, College of Physicians and Surgeons, Columbia University; Associate Visiting Physician, Presbyterian Hospital, New York City.

FREDERICK P. HENRY, A.M., M.D., PHILADELPHIA, PA.
Professor of Principles and Practice of Medicine, Woman's Medical College of Penna.

C. JUDSON HERRICK, B.S., M.S., PH.D., CHICAGO, ILL.
Professor of Neurology, University of Chicago; Managing Editor, Journal of Comparative Neurology.

HOUSTON B. HIATT, M.D.,..HIGHPOINT, N. C.

ROSE HIRSCHLER, M.D.,.....PHILADELPHIA, PA.
Dermatologist, Woman's Hospital of Philadelphia.

FREDERICK L. HOFFMAN, LL.D., NEWARK, N. J.
Statistician, Prudential Insurance Company of America.

EDGAR M. HOLMES, M.D.,....BOSTON, MASS.
Aural Surgeon, Boston Dispensary and Boston City Hospital; Consulting Aural Surgeon, Massachusetts Infant's Asylum; Surgeon, Diseases of Ear, Nose and Throat, St. Elizabeth's Hospital.

WILLIAM H. HOWELL, A.B., PH.D., M.D., LL.D., SC.D., BALTIMORE, MD.
Professor of Physiology and Dean of the Medical Faculty, Johns Hopkins University; Associate Editor, American Journal of Physiology.

JOHN B. HUBER, A.M., M.D.,....NEW YORK.
Professor of Pulmonary Diseases, Fordham University Medical School; Lecturer on Tuberculosis, State Health Department; Visiting Physician, St. Joseph's Hospital for Consumptives.

OTTO V. HUFFMAN, M.D.,....ALBANY, N. Y.
Secretary, State Board of Medical Examiners, University of the State of New York.

GEORGE THOMAS JACKSON, M.D., NEW YORK.
Professor of Dermatology, College of Physicians and Surgeons, Columbia University; Consulting Dermatologist, Presbyterian Hospital and the New York Infirmary for Women and Children.

ESTHER L. JEFFERIS, M.D.,....NEW YORK.
Assistant Physician, Babies' Hospital, O.P.D.; Formerly Chief of Clinic, Department of Pediatrics, O.P.D., New York Infirmary for Women and Children.

SMITH ELY JELLIFFE, A.M., M.D., PH.D., NEW YORK.
Adjunct Professor Diseases of the Mind and Nervous System, Post-Graduate Medical School; Visiting Neurologist, City Hospital.

J. ELLIS JENNINGS, M.D.,.....ST. LOUIS, MO.
Professor of Ophthalmology, Medical Department, National University; Ophthalmic Surgeon, Centenary Hospital; Ophthalmic and Aural Surgeon, St. Louis and San Francisco Ry. System; Ophthalmologist, Visiting Staff of the City Hospital.

JAMES C. JOHNSTON, M.D.,.....NEW YORK.
Surgeon Cornell Dispensary, Department of Dermatology.

ROBERT C. KEMP, M.D.,.....NEW YORK.
Consultant, Gastrointestinal Diseases, Manhattan State Hospital; Visiting Gastroenterologist, Fordham University Clinic.

J. H. MASON KNOX, JR., M.D.,....BALTIMORE, MD.
Associate Professor Pediatrics, Johns Hopkins Medical School; Physician in Charge, The Thomas Wilson Sanatorium for Children.

GEORGE W. KOSMAK, M.D.,.....NEW YORK.
Attending Surgeon, Lying-in Hospital.

O. F. KREHBIEL, M.D.,.....NEW YORK.
Attending Physician, German Dispensary.

LINNAEUS E. LA FETRA, M.D.,.....NEW YORK.
Visiting Physician, Children's Department, Bellevue Hospital; Consulting Pediatrist, Skin and Cancer and Italian Hospitals.

WILLIAM G. LE BOUTILLIER, M.D., NEW YORK.

ROBERT LEWIS, M.D.,.....NEW YORK.
Aural Surgeon, N. Y. Eye and Ear Infirmary; Consulting Otologist, St. Francis and Flushing Hospitals.

J. F. LEYS, M.D.,.....UNITED STATES NAVY.
Formerly Superintendent Colon Hospital, Isthmian Canal Commission, and President Medical Association of the Canal Zone.

DOUGLAS C. McMURTRIE,.....New York.
Secretary, American Association for the Conservation of Vision.

GEORGE ELMER MALSBARY, M.D.,....Los. Angeles, Cal.
Editor of the Southern California Practitioner.

CHARLES H. MAY, M.D.,.....New York.
Ophthalmic Surgeon, Mt. Sinai Hospital; Consulting Ophthalmic Surgeon to Bellevue, French, Italian and Red Cross Hospitals.

THOMAS J. MAYS, M.D.,.....Philadelphia, Pa.
Medical Director, Philadelphia Clinic for Chest and Throat Diseases.

J. EWING MEARS, A.B., B.S., A.M., M.D., LL.D., Philadelphia, Pa.
Formerly Lecturer on Practical Surgery and Gynecology, Jefferson Medical College.

MORRIS BOOTH MILLER, M.D., Philadelphia, Pa.
Professor of Surgery, Philadelphia Polyclinic and College for Graduates in Medicine; Surgeon, Douglas Memorial Hospital.

WILLIAM S. MILLER, M.D.,....Madison, Wis.
Professor of Anatomy, University of Wisconsin.

CHARLES SEDGWICK MINOT, B.S., LL.D., Sc.D., Boston, Mass.
James Stillman Professor of Comparative Anatomy, Harvard Medical School.

WILLIAM O. MOORE, M.D.,.....New York.
Ophthalmic Surgeon, Post-Graduate and Flushing Hospitals; Consulting Ophthalmic and Aural Surgeon, Orphan's Home and Asylum P. E. Church.

ROGER S. MORRIS, M.D., Clifton Springs, N. Y.
Chief of the Medical Department and Director of the Laboratory, Clifton Springs Sanatorium.

HERMAN O. MOSENTHAL, M.D.,....New York.
Assistant Attending Physician, Presbyterian Hospital; Attending Physician, Vanderbilt Clinic.

GEORGE M. NILES, M.D.,.....Atlanta, Ga.
Professor of Gastroenterology and Clinical Medicine, Atlanta Medical College.

EDWARD O. OTIS, M.D.,.....Boston, Mass.
Professor of Pulmonary Diseases and Climatology, Tufts College Medical School; Late Visiting and Consulting Physician to the Massachusetts State Sanatorium; Ex-president of the American Climatological Association; Physician to the Department of Tuberculosis of the Lungs, Boston Dispensary.

WILLIAM HALLOCK PARK, A.B., M.D., LL.D., New York.
Professor of Bacteriology and Hygiene, University and Bellevue Hospital Medical College; Director, New York Health Department, Research Laboratories; Medical Examiner in Hygiene, State Department of Education.

ARTHUR S. PEARSE, Ph.D.,....Madison, Wis.
Associate Professor of Zoology, University of Wisconsin; Instructor in Zoology, Marine Biological Laboratory, Woods Hole, Mass.

WILLIAM F. R. PHILLIPS, M.D.,....Mobile, Ala.
Professor of Anatomy, University of Alabama, School of Medicine.

EDWARD PREBLE, M.D.,.....New York.

HENRY E. RADASCH, M.Sc., M.D., Philadelphia, Pa.
Associate Professor of Histology and Embryology, Jefferson Medical College.

BURTON ALEXANDER RANDALL, A.B., A.M., M.D., Philadelphia, Pa.
Formerly Eye and Ear Surgeon, Methodist Hospital.

JAY MORRISON RAY, M.D.,.....Louisville, Ky.
Professor of Diseases of the Eye, Ear, Nose and Throat, University of Louisville, Medical Department.

HENRY O. REIK, M.D.,.....Baltimore, Md.

JOSEPH CHARLES ROPER, M.D.,....New York.
Associate Physician, New York Hospital; Instructor in Medicine, Cornell University Medical College in New York City.

HENRY H. RUSBY, M.D.,.....Newark, N. J.
Dean and Professor of Botany, Physiology, and Materia Medica, New York College of Pharmacy; Pharmacognosist at the Port of New York for the U. S. Department of Agriculture; Chairman, Scientific Directors, N. Y. Botanical Garden.

WORTHINGTON SEATON RUSSELL, M.D., New York.
Research Fellow and Chief of the *X*-ray Department, New York Skin and Cancer Hospital; Professor of Materia Medica and Therapeutics, and Director of the *X*-ray Department, College of Dental and Oral Surgery of New York; Pathologist to the Tarrytown Hospital.

R. J. E. SCOTT, M.D.,.....New York.
Formerly Gynecologist, Demilt Dispensary; and Attending Physician, Out-patient Department, Bellevue Hospital.

JOHN E. SHEPPARD, M.D.,.....Brooklyn, N. Y.
Consulting Surgeon, Brooklyn Eye and Ear, Jewish, Methodist Episcopal and St. Catharine's Hospitals, Aurist, Long Island College Hospital.

J. GARLAND SHERRILL, M.D., Louisville, Ky.
Professor of Surgery and Clinical Surgery, University of Louisville, Medical Department.

DANIEL K. SHUTE, A.B., M.D., Washington, D. C.
Professor of Anatomy and Clinical Professor of Ophthalmology, George Washington University.

J. MORRIS SLEMONS, M.D., San Francisco, Cal.
Professor of Obstetrics and Gynecology, University of California; Director of the Woman's Clinic, University of California Hospital.

H. BEAUMONT SMALL, M.D., Ottawa, Canada.
Attending Physician, St. Luke's Hospital, Ottawa; Late Examiner in Materia Medica, College of Physicians and Surgeons, Ontario.

ERNEST E. SMITH, M.D.,.....New York.
Assistant Gynecologist, New York Polyclinic; Pathologist, Somerset and Jamaica Hospitals.

WILLIAM BENHAM SNOW, M.D.,...New York.
Editor, Journal of Advanced Therapeutics.

ALEXANDER SPINGARN, A.M., M.D., Brooklyn, N. Y.
Attending Physician, Kingston Avenue Hospital for Contagious Diseases; Attending Pediatrist, Bushwick and East Brooklyn Dispensary; Assistant Editor, Medical Record.

THOMAS L. STEDMAN, A.M., M.D., New York.
Editor, Twentieth Century Practice of Medicine; Editor, Medical Record.

RALPH G. STILLMAN, M.D.,.....New York.
Attending Physician, Seton Hospital; Clinical Pathologist and Attending Physician to Contagious Diseases, New York Hospital; Department Attending Physician, New York Hospital, O.P.D.

CHARLES R. STOCKARD, M.S., Ph.D., New York.
Professor of Anatomy, Cornell University Medical College.

GEORGE C. STOUT, M.D., PHILADELPHIA, PA.
Chief, Department of Otology and Laryngology, Presbyterian Hospital.

HENRY L. SWAIN, M.D., ....NEW HAVEN, CONN.
Laryngologist to the New Haven Dispensary and New Haven Hospital; Clinical Professor of Diseases of Ear and Throat, Yale Medical School.

TERRY M. TOWNSEND, M.D., .NEW YORK.

FRANK P. UNDERHILL, PH.D., NEW HAVEN, CONN.
Assistant Professor of Physiological Chemistry, Sheffield Scientific School of Yale University; Professor of Pathological Chemistry, Department of Medicine, Yale University; Chemist to the New Haven Hospital.

ALBERT VANDER VEER, M.D.,....ALBANY, N. Y.
Professor of Surgery, Albany Medical College.

KARL M. VOGEL, PH.G., M.D.,.....NEW YORK.
Assistant Professor of Clinical Pathology, Columbia University; Assistant Attending Physician and Clinical Pathologist, St. Luke's Hospital.

IRVING WILSON VOORHEES, M.S., M.D., NEW YORK.
Adjunct Professor of Otology, Fordham University.

EMMA E. WALKER, A.B., M.D.,.....NEW YORK.
Assistant Surgeon, Hospital for the Relief of the Ruptured and Crippled.

ALDRED SCOTT WARTHIN, PH.D., M.D., ANN ARBOR, MICH.
Professor of Pathology and Director of the Pathological Laboratories, University of Michigan

JOHN E. WEEKS, M.D.,.....NEW YORK.
Professor of Diseases of the Eye, University and Bellevue Hospital Medical School, New York University; Surgeon, New York Eye and Ear Infirmary; Consulting Ophthalmic Surgeon, Bellevue Hospital and Vassar Brothers' Hospital, Poughkeepsie, N. Y.

CARL V. WELLER, A.B.,.....ANN ARBOR, MICH.
Instructor in Pathology, University of Michigan, Department of Medicine.

H. GIDEON WELLS, M.D.,.....CHICAGO, ILL.
Associate Professor of Pathology, University of Chicago

GROVER W. WENDE, M.D.,....BUFFALO, N. Y.
Professor of Dermatology, University of Buffalo; Physician to the Sisters', County, and German Hospitals and to the University Dispensary.

CHARLES J. WHITE, A.B., M.D.,..BOSTON, MASS.
Physician, Diseases of the Skin, Massachusetts General Hospital; Assistant Professor in Dermatology, Harvard; Consulting Dermatologist, Boston Insane Asylum.

WILLIAM A. WHITE, M.D.,..WASHINGTON, D. C.
Superintendent, Government Hospital for Insane; Professor of Nervous and Mental Diseases, George Washington University; Lecturer on Insanity, U. S. Naval and Army Medical Schools.

HENRY H. WHITEHOUSE, M.D.,....NEW YORK.
Attending Physician, Skin and Cancer Hospital; Consulting Dermatologist, St. Mary's Hospital, Hoboken, and Home for the Friendless.

ROYAL WHITMAN, M.D.,.....NEW YORK.
Adjunct Professor, Orthopedic Surgery, College of Physicians and Surgeons (Columbia); Professor of Orthopedic Surgery, New York Polyclinic Medical School; Associate Surgeon, Hospital for Ruptured and Crippled; Orthopedic Surgeon to Hospital St. John's Guild; Consulting Surgeon, St. Agnes Hospital and New York Home for Crippled Children.

EDWARD M. WILLIAMS, M.D., SIOUX CITY, IOWA.
Formerly Instructor in Neurology and Neuropathology, University of Pennsylvania.

CHARLES F. WITHINGTON, A.B., M.D., BOSTON, MASS.
Visiting Physician, Boston City Hospital; Consulting Physician, Boston Insane Hospital, N. E. Hospital for Women and Children, and Choate Memorial Hospital, Woburn.

ABRAHAM L. WOLBARST, M.D.,....NEW YORK.
Consulting Genito-urinary Surgeon, Central Islip State Hospital; Visiting Genito-urinary Surgeon, People's Hospital, and Beth Israel Hospital Dispensary.

**Chloroma.**—*Cancer vert.* A tumor belonging to the general class of sarcoma, more precisely to the group of lymphoma, lymphosarcoma, so-called leukemic and pseudoleukemic tumors, etc. The name was given by King, of Glasgow, in 1853, and indicates the remarkable color of the new growth, which is usually a bright green. Chloroma is remarkable for the frequency with which it affects the periosteum of the cranium, especially in the orbital and temporal regions and in the dura. Various other parts of the periosteum are also frequently affected, besides the lymph glands, bone marrow, liver, kidneys, spleen, lungs, pleura, and other organs. In some cases the tumors have first been discovered in peripheral organs such as the mammary gland or the axillary lymphatic glands, but even in such cases it is probable that the primary growth is in the periosteum of the cranium. The new growth has a tendency to invade the connective tissue, involving fasciæ, tendons, etc., and sometimes forms very extensive infiltrations. In structure the tumor consists of a fine reticulum in which cells of the size and character of lymphocytes lie, traversed by bands of connective tissue continuous with that of the seat. The consistence varies from very soft to very hard, depending chiefly on the connective tissue. The cause of the green color is not known. According to some it is a fat pigment; others compare it to the pigment of green pus. Chloroma occurs especially in early life, although a number of cases have been observed in middle life. More cases have been observed in males than in females.

Clinically, chloroma is characterized by rapidly increasing anemia with petechiæ, nosebleed, and sometimes scorbutic symptoms; by loss of weight, fever, headache, deafness, tinnitus aurium, blindness and double vision, and by facial paralysis and exophthalmus. Many cases have been first seen in eye or ear clinics, on account of the special symptoms mentioned, and it is possible that in some cases not examined anatomically the disease has been mistaken for an ordinary orbital sarcoma. In a number of cases increase of leucocytes has been observed, and this occurs in two types. In one the increase affects especially mononuclear cells having the general character of lymphocytes, the appearance of the blood in other respects closely resembling that in cases of so-called acute leukemia. In the other the blood resembles that in myelogenous leukemia. The histological picture varies according to the predominance of lymphoid or myeloid cells. Peculiar nuclear forms in the large cells have been described by Butterfield, confirmed by Libmann. The course of the disease is rapid and progressive. The changes in the blood and the structure of the tumors have led a number of observers to assign chloroma to the group of diseases including leukemia, pseudoleukemia, certain cases of lymphosarcoma, and some of the tumors described as myeloma. Many writers prefer to look upon it as a disease of the lymphatic hematopoietic system, and to speak of it as chlorolymphadenosis or chloromyelosis. Ignorance of the etiology of all of these processes makes a definite opinion impossible at this time. The idea of bacterial infection is very strong, but positive proof is as yet absent.

Chloroma should be recognized in most cases comparatively early on account of the striking combination of symptoms, especially from the coexistence of anemia with or without increase of lymphocytes, the characteristic new growths in the orbital and temporal region, the ear symptoms, and others mentioned above. In cases discovered early, efforts should be made to use *x*-rays, possibly benzole, as in the treatment of leukemia.

Most of the observations on chloroma are referred to in articles of Dock, *American Journal of the Medical Sciences*, August, 1893; Lang, G., *Archives générales de Médecine*, November *et seq.*, 1893, and July–September, 1898; and Lenndorff, H., *Ergebnisse der inneren Medizin*, 1910, Bd. vi., p. 221.

George Dock.

**Chlorosis.**—Definition.—A disease of unknown cause, affecting young girls at about the time of puberty, with a tendency to recur, and producing an anemia characterized by a marked lowering of the color index.

Etiology.—Though the disease has been recognized as a clinical entity for centuries, chlorosis remains an etiological puzzle. Its cause is wholly obscure. That it is related in some manner to the female generative organs is suggested by the fact that the disease occurs exclusively in women; no authentic case of chlorosis in the male has been recorded. It occurs about the time of puberty, usually between the sixteenth and twenty-first years. The disease is observed frequently in the third decade, occasionally in the fourth, but rarely later. Instances of the disease in patients beyond the age of twenty-one or twenty-two years represent recurrences, as a careful anamnesis usually indicates. The disease may develop spontaneously in spite of ideal hygienic conditions; it affects all classes, though relatively less frequent in the well-to-do and in country girls. Various causes have been held responsible for the disease. Hypoplasia of the heart and arteries (Virchow), gastroptosis (Meinert), constipation (Clark) are a few of the conditions which have been supposed to bear an etiological relationship to chlorosis, but none of them has been proved to be of importance.

A remarkable fact regarding chlorosis is that it seems to be disappearing in the United States. Cabot has recently called attention to this, and it is borne out by the experience of clinicians in all parts of the country. The reduction in the number of cases at the Massachusetts General Hospital within the last decade has been striking, and Cabot finds similar statistics from other large hospitals.

Pathology.—As chlorosis is rarely fatal, details of its pathology are meager. Grawitz found the bone marrow from the tibia of two cases practically normal macroscopically and microscopically. That there is not increased hemolysis seems certain; no evidence of it has been found in the blood serum of chlorotics, and urobilin does not appear in the urine in pathological amounts. There are no data regarding the presence or absence of siderosis of the liver, as Naegeli points out.

Symptoms.—The onset of the disease in the great majority of cases is slow and insidious. The earliest symptoms are generally dyspnea on exertion, muscular weakness and drowsiness; at this stage there may be no demonstrable alterations in the blood, whose corpuscular richness and hemoglobin content may be normal. As the disease progresses, the symptoms become aggravated, others make their appearance, and there gradually develops an anemia, causing marked pallor and characterized by a reduction in the hemoglobin out of all proportion to the decrease in the number of red cells.

In mild cases of chlorosis there is little or no change in the blood. The hemoglobin is between eighty and ninety per cent., essentially normal values, with 4,500,000 to 5,000,000 erythrocytes. Nevertheless, the patients may suffer from dyspnea on exertion, dyspepsia, drowsiness, weakness, etc. It is such cases which have led Morawitz to suggest that the anemia is not the primary disorder but rather a secondary manifestation of the disease.

Moderately severe cases show a well-defined pallor as a rule, though instances of so-called chlorosis rubra are occasionally observed. The skin is pale and white, at times—especially in brunettes—with a definitely greenish-yellow tint (whence the name, chlorosis). The mucous membranes are likewise pale. The hemoglobin is reduced to about forty to sixty per cent. The red cell count is in the neighborhood of 3,500,000 or 4,000,000. There is, therefore, a marked lowering of the color index. The patient may complain of headache, palpitation of the heart, dyspnea on exertion, lassitude, black specks before the eyes, dyspepsia, constipation and menstrual disturbances. Hysterical symptoms are not uncommon.

In severe cases of chlorosis all the symptoms are aggravated, there may be tinnitus aurium, vertigo, syncopal attacks, edema of the ankles, anorexia. Fever is not uncommon in the moderately severe and severe cases. It occasionally rises to 101° F., and in severe cases may be continued (Cabot). In spite of the marked anemia, the nutrition is well preserved.

*Skin.*—The pallor of the skin has already been mentioned. It is perhaps the most noticeable feature in the appearance of the chlorotic and, in connection with the usual plumpness of figure, often suggests the nature of the malady. Generally, the color of the skin is alabaster white, at times with a yellowish tint. Though a greenish shade is not the rule by any means, one cannot agree with Cabot that it takes "the eye of faith" to see it. In a recent case the greenish tint of the skin was so evident that it was remarked by several of the patient's friends. Acne is at times a complication. Pigmentation of the skin may occur. The nail beds and mucous membranes are pale, usually even in the cases of chlorosis rubra with flushed cheeks.

*Eyes.*—The patient often complains of black vision or black specks before the eyes. The eyes tire rapidly when the patient reads. The eye-grounds are pale. Retinal hemorrhages are uncommon, though they have been recorded by Naegeli in two recent moderately severe cases of chlorosis. The sclerotics are white, often with a bluish tint.

*Circulatory System.*—Palpitation of the heart is an almost constant symptom in moderately severe and severe cases and is complained of at times from the onset of the disease. With the development of the anemia there is usually a systolic murmur audible at the pulmonic area or apex, at times over the entire precordia. In severe cases there is often dilatation of the heart with enlargement of dulness both to the right and to the left. Coincidently, a relative mitral insufficiency may be produced, though it is comparatively uncommon. The pulse is regular, often increased in frequency, large, easily compressible, and moderately quick. A capillary pulse is seen at times. A continuous venous hum, best heard over the right side of the neck, is usual after the anemia has become established; a thrill may be palpable. The recent observations of Matsuo show that in anemia in general a venous hum is present as a rule, when the viscosity of the blood falls to 2.8 or less, to disappear usually as the viscosity rises above 3.0 or 3.1. Thrombosis may occur, especially in the veins of the lower extremity, rarely in the arm. Thrombosis of a cerebral sinus may prove fatal. Edema of the ankles is common with marked anemia.

*Respiratory System.*—Dyspnea on exertion, as mentioned above, is often one of the earliest symptoms. Allbutt looks upon it as perhaps the most constant symptom of the disease. With the severer grades of anemia the respirations may be somewhat increased in frequency.

*Digestive Tract.*—There may be anorexia. More often the appetite is capricious; the patients exhibit a predilection for pickles, chalk, sand, sulphur, magnesia, wood, etc. Nausea and vomiting may be complained of, and gastric analysis frequently reveals hyperacidity. Arneth has shown that the degree of hyperacidity is usually inversely proportional to the hemoglobin value. Ulcer of the stomach may be met with as a complication of the disease. Constipation is the rule.

*Menstrual disturbances* usually appear as the anemia becomes evident. Amenorrhea is the commonest, though the flow may be merely diminished in amount. Irregularity is frequent. Less common are menorrhagia and dysmenorrhea.

*Urine.*—A trace of albumin may be found in the urine, together with an occasional hyaline cast. Otherwise the urine is normal.

*Blood.*—In the mildest cases of chlorosis there may be no alteration of the blood or, at most, a slight reduction in the hemoglobin. As the anemia develops, the blood looks pale as it flows from the puncture wound. On examination there is found a decrease in hemoglobin which is relatively much greater than the diminution in number of the red blood corpuscles, giving rise to a low color index, usually in the neighborhood of 0.5, occasionally much lower. This is the most characteristic feature of chlorotic blood. It is found with great constancy and explains the pallor of the erythrocytes, which is evident both in fresh and stained preparations. The delle of the corpuscle is much enlarged, leaving a comparatively narrow rim of hemoglobin about the periphery of the corpuscle. There is considerable variation in size of the corpuscles—anisocytosis. Large, pale cells, ten to twelve micra in diameter, may be seen, but the majority of the corpuscles are smaller than normal. This fact is established not only by measurements of the cells but also by the lowering of the volume index, which Capps has shown is the rule in chlorosis. As the condition of the blood improves, the volume index rises. Poikilocytosis is fairly constant with a well-developed anemia. In severe cases it may be very marked.

Polychromasia of the red cells is not infrequently seen. Basophilic granules are less common but occur in severe cases. Naegeli finds that they may be increased after the beginning of iron therapy. Cabot's ring bodies and nuclear particles have not been described in the blood of chlorosis. Naegeli, however, has observed fine chromatin dots in some of the poly-

chromatophilic cells. Erythroblasts are rather uncommon. Blood crises apparently do not occur. In the severe cases normoblasts may be found; they are less apt to occur in those of moderate severity. In Otten's series of 700 cases they were noted only eight times, but the majority of observers have encountered normoblasts rather more frequently. Megaloblasts are excessively rare, but they have been found in very severe cases of chlorosis (Arneth.)

Blood platelets are increased in number as a rule. To this fact has been attributed the tendency of chlorotics to venous thrombosis, though a causal relationship remains to be proved. Outside the body the blood clots more slowly than normal.

The leucocytes show little change in number or formula. The count lies usually between 5,000 and 10,000. Occasionally there is a leucopenia, with a relative increase of the lymphocytes. In severe cases a few neutrophilic myelocytes may be found. Thrombosis leads to a neutrophilic leucocytosis. During improvement Naegeli finds relatively high total counts with an increase in the number of eosinophiles.

Diagnosis.—The correct diagnosis may often be surmised from the appearance of the patient. The pallor of the skin, at times with a greenish-yellow tint, the well-nourished condition of the patient, the bluish-white sclerotics are highly suggestive. An absolute diagnosis can be made, however, only by finding the characteristic blood changes, together with the lack of any discoverable cause of anemia. The diagnosis cannot be made with certainty from a study of the blood alone; similar alterations may be observed in secondary anemias, though it is true that in the majority of cases the lowering of the color index is not so marked as in chlorosis. While, therefore, the blood findings in themselves are insufficient data for a positive diagnosis, it is equally true that a diagnosis of chlorosis is unjustifiable in the absence of the usual blood picture, particularly the lowering of the color index.

Cardiac disease may be suggested by the palpitation, swelling of the ankles, and dyspnea on exertion. Examination of the blood and of the heart reveals the true nature of the affection.

The secondary anemias of chlorotic type most likely to be mistaken for true chlorosis are those associated with early pulmonary tuberculosis, nephritis, and, possibly, hookworm disease. At times a color index in the neighborhood of 0.5 is found, though as a rule the reduction is less marked.

From pulmonary tuberculosis chlorosis is differentiated by the absence of physical signs in the lungs. If doubt still exists, a tuberculin test may be employed.

Nephritis causing sufficient pallor and edema to be confused with chlorosis is practically always associated with a considerable amount of albumin in the urine and a variety of casts, whereas in chlorosis the albumin is usually present only in traces and hyaline casts—occasionally finely granular as well—alone are observed. The secondary cardiovascular changes of advanced nephritis are lacking in chlorosis.

Chlorosis may at times be suggested by the history of a patient suffering with hookworm disease. The appetite is often capricious, lassitude and drowsiness may be marked. There may be little emaciation. The color of the skin is muddier than it is in chlorosis, the sclerotics have not the bluish tint, and the lowering of the color index is not so extreme in the great majority of cases. Eosinophilia may be found. The certain differentiation is made by finding the ova of the parasite in the feces.

Other intestinal parasites less frequently cause an anemia resembling chlorosis. The writer has observed one patient infected with *Strongyloides stercoralis*, whose blood was typical of a moderately severe chlorosis, except for the presence of a marked eosinophilia. The feces contained the rhabditiform embryos of the parasite.

Course and Prognosis.—Chlorosis is essentially a chronic disease. The onset is gradual and it may be months before the patient seeks the physician for relief. Once the specific therapy is begun, the recovery is prompt, as a rule. There is a marked tendency to recurrence of the disease, a fact which should be impressed upon the patient before she is finally discharged, so that treatment may be instituted before the anemia has again become severe.

The prognosis is usually good. Uncomplicated chlorosis is seldom fatal. Death occurs most frequently from thrombosis of a cerebral sinus.

Treatment.—Chlorosis is one of the few diseases for which we possess a specific remedy. Iron in practically any of its forms induces a cure. The majority of clinicians at the present time seem to be united in agreeing that the official five-grain Blaud's pill (pilula ferri carbonatis) is the best form in which to administer the iron. At the beginning of treatment one pill is given three times a day after meals for one week, then two pills thrice daily for a week, and finally three pills three times a day; the last dose is maintained for three weeks or a month—in severe cases it may be increased to four pills at a dose—and then the number of pills is decreased by one at intervals of a week. If the hemoglobin is still low—say, below sixty per cent., after two or three weeks the graduated increase in the dose is again instituted. After the hemoglobin has risen to seventy per cent. or more, the drug should be continued, one pill three times a day, for six to eight weeks. The stomach is seldom upset by the Blaud's pill. It is remarkable to note the rapidity in improvement of the subjective symptoms, which are often entirely relieved at a time when the hemoglobin is still well below normal. As soon as evidence of a recurrence is noted, iron therapy should be begun again. In severe cases the patient should be confined to bed.

For the hyperacidity so frequently associated with chlorosis, alkalies may be administered. Olive oil or cream, two teaspoonsful quickly increased to an ounce, taken fifteen minutes before meals, often gives relief.

The bowels, which are usually constipated, require regulating.

The menstrual disturbances usually disappear with the improvement of the anemia.

Roger S. Morris.

**Chlorsalol.**—Chlorophenol salicylate, $C_6H_4.OH.COO.C_6H_4Cl$. It is made by the reaction between phosphorus pentachloride and a mixture of salicylic acid and parachlorphenol. Chemically it is salicylic-parachlorphenol-ester. It has been used, in place of salol, in cystitis, diarrhea, and as an intestinal and urinary antiseptic. The dose by mouth is twenty to thirty grains three times a day.

R. J. E. Scott.

**Choanoflagellata.**—A division of the subclass *Zoomastigophora*, class *Mastigophora*, which includes simple flagellates with a well-defined and characteristic protoplasmic collar surrounding the base of the flagellum; they frequently form colonies in which the cells are imbedded in a matrix of jelly or chitin. See *Protozoa*. A. S. P.

**Choked Disc.**—This is a condition of the optic nerve head having a characteristic appearance; it is known by various other names: papillitis, congestion papilla, "Stauungspapille," intraocular optic neuritis; this latter is the better name.

Formerly two kinds of papillitis were spoken of, choked disc and descending neuritis. When the symptoms were confined to the intraocular end of the optic nerve, with great swelling of its substance, and the appearance of marked congestion, with the retinal veins swollen and tortuous, the term "choked disc" was given to the condition.

There are no external appearances in the way of pupillary changes or signs in the forms of intraocular optic neuritis.

The vision, even when the ophthalmoscopic appearances are most marked, may be normal, while on the other hand in less marked cases, the vision may be reduced to perception of light. These differences in the degree of vision depend upon the extent to which the nerve elements of the inflamed part are pressed on, and cannot be told by the ophthalmoscopic appearances. The field of vision is at first normal but may later become concentrically or irregularly contracted.

The ophthalmoscopic appearances are in all cases, hyperemia and swelling of the optic nerve head, loss of light spot, obscuration of the margins of the optic nerve, the center being redder than the periphery: the swelling of the disc is mound shaped, or mushroom in form and appearance, with white patches and spots seen in the elevation. The arteries are smaller than normal and much obscured, pulsation is occasionally visible, the veins are dark in color, twisted, and tortuous, sometimes remarkably so, so that the optic disc with the swelling and vessels has been termed "Medusa head," as it resembles crawling snakes.

The edges of the nerve head have a woolly appearance, and grayish striæ extend from the disc into the adjacent retina. Hemorrhages are seen sometimes on the swollen papilla and are in the fiber layer, they are found in various shapes, occasionally small white spots are found in the macula lutea region similar to those seen in nephritic retinitis.

Postmortem examination in many cases of intracranial disease shows choked disc to be an inflammation of the optic papilla, with a high degree of hyperemia, edema, hypertrophy of the nerve fibers, infiltration of lymph cells, and connective-tissue changes; this condition extends in some cases to the trunk of the nerve and its sheaths.

*Symptoms.*—The diagnosis is made by the ophthalmoscope only, as the patient may have perfect vision, and no eye symptoms; the most common general symptom is severe pain in the head varying in locality according to the intracranial cause.

The onset is usually sudden, although there are cases reported where it seems to have been chronic, and the failure of vision progressive.

The elevation of the optic nerve head can be measured by the ophthalmoscope, hyperopia of 1D is equivalent to one millimeter elevation.

*Etiology.*—The most common cause of choked disc is tumor of the brain, but the intensity of the inflammation of the optic nerve seems to bear no relation to the size of the tumor or its situation.

New growths or abscesses in the cerebellum seem to produce more severe eye symptoms than tumors of the convexity of the brain; choked disc has not been found associated with tumors of the medulla oblongata.

It may be produced by orbital tumors, or any of the acute febrile affections; it has been seen as a congenital condition, in several of the same family, and occurs without apparent cause.

Various theories have been advanced as to the optic nerve swelling, the pressure theory being the one most accepted; clinically we find that engorgement plays the most important part in the production of choked disc, while at the same time inflammation of the optic nerve and its sheath add to the condition.

*Treatment* consists in combating the cause in each case, when due to syphilitic tumors of the brain, by antisyphilitic treatment, when due to abscess of the cerebellum by proper surgical measures, when due to rheumatism by antirheumatic remedies, and so on.

Lumbar puncture has been found to diminish the swelling of the nerve head.

Trephining has been advised to prevent blindness due to pressure, some going so far as to say that no case of optic neuritis not due to infectious disease or toxemia should go to blindness without an operation to relieve the pressure.

The *prognosis* for vision is bad, while the intracranial cause may threaten the patient's life. In most cases atrophy of the optic nerve results, the degree varying according to the severity of the inflammatory process, and its duration.

WILLIAM OLIVER MOORE.

**Cholagogues.**—See *Cathartics.*

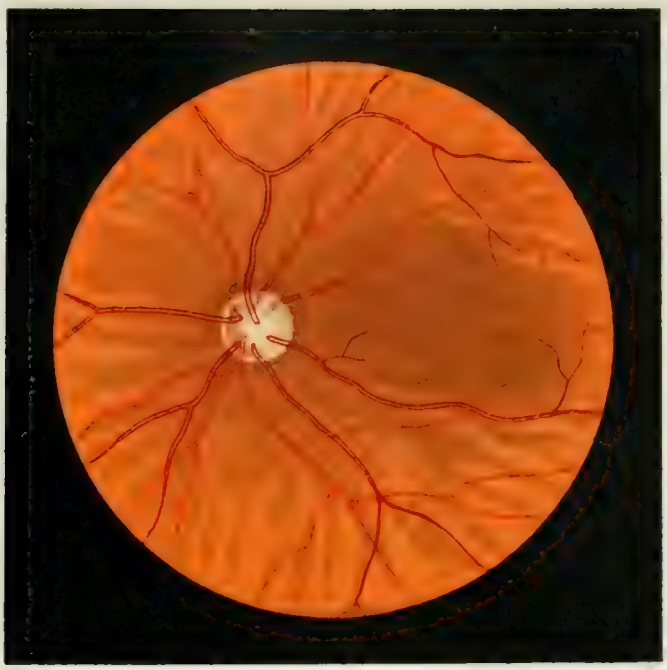
**Cholemia.**—The term cholemia (χολή, bile + αἷμα, blood) denotes the presence of bile salts in the circulating blood. This should be considered a symptom rather than a disease. Usually there are severe nervous symptoms, but sometimes these are slight or apparently absent in the presence of marked cholemia.

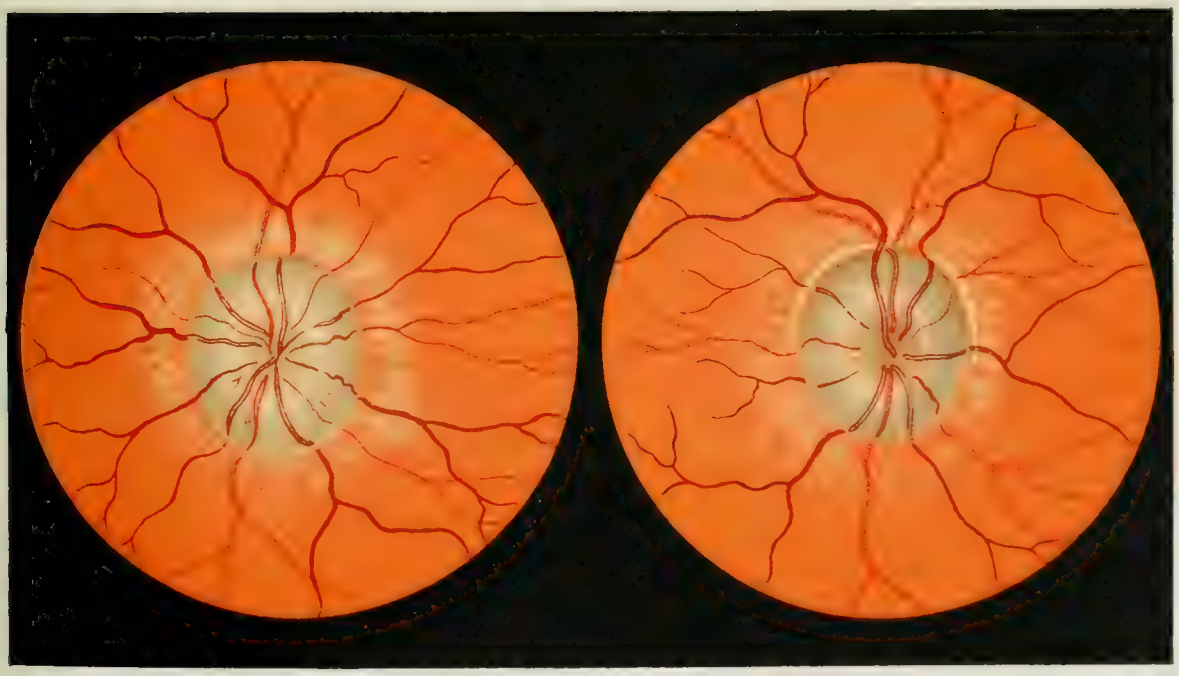
CONGENITAL FAMILY CHOLEMIA.—A most interesting form of this affection is that known as congenital family cholemia. In this disease a splenic tumor is one of the most characteristic features, in the vast majority of cases. It is stated that several cases have been reported as splenic anemia. Usually the enlargement of the spleen appears early and is marked, extending to the umbilicus or beyond. In a few cases, in which there seems no other reason to doubt the diagnosis, there has been no apparent enlargement of the spleen.

In congenital family cholemia, bile has been demonstrated in the blood in all cases in which it was looked for. Urobilin is absent. The red blood cells show diminuition of resistance, marked by more ready hemolysis. This may be readily tested by washing the red cells in hypertonic and hypotonic saline solution, noting the point at which hemolysis takes place. Normal blood begins to show hemolysis at about four per cent. saline solution, whereas in congenital family cholemia hemolysis of the red cells may begin at seven per cent. or even nine per cent. saline solution. On the other hand, it has been shown that the resistance of the red cells to hemolysis is definitely increased in obstructive jaundice. There is no characteristic change in the leucocytes. Some cases show a polymorphonuclear leucocytosis, and others a relative lymphocytosis. Myelocytes are frequently present in small numbers, and have been noted as high as nine per cent. Mast cells have frequently been observed in small numbers. The hemoglobin is diminished in proportion to the red cells, the color index being usually normal or a little less.

Jaundice has been present in all the recorded cases of congenital family cholemia, and is regarded as an essential feature in diagnosis. However, some of the members of affected families have shown only anemia, a splenomegalia without jaundice. But jaundice is the rule, varying in intensity from a mere tinging of the conjunctiva to the marked hue of catarrhal jaundice. There is never the green or black jaundice, such as occurs in malignant or congenital obstruction of the bile ducts. In the presence of the more intense jaundice, there is often a heavy deposit of urates in the urine. There is a diminution of the sense of well being, and the condition seems to be aggravated by physical, mental, and dietetic excesses.

In congenital family cholemia, bile is usually present in the urine, though in a few cases it has been reported present in only small quantities at intervals. Uro-





Representation (in the two lower pictures) of the condition known as "Choked Disk," as seen with the ophthalmoscope. For purposes of comparison, the appearance of the normal fundus oculi is shown in the upper picture.—*(From Haab—Atlas of Ophthalmoscopy.)*

American Lithographic Co. N. Y.

bilin is generally present. The presence of urates with exacerbations has been mentioned.

The stools are colored in congenital family cholemia. There is increased excretion of urobilin through both the urine and feces. The biliary coloring of the feces increases with the jaundice.

In a few cases of congenital family cholemia, enlargement of the liver has been noted, roughness and irregularities of the liver have not been observed.

Congenital family cholemia in many cases is marked by the absence of distress, the patient being impelled to call upon the physician solely by the change in color. In general, there is apparently less discomfort than in the acquired cases of cholemia, in which it is rather the exception for the patient to be without unpleasant symptoms for any length of time. Repeated attacks of epistaxis are not uncommon; hemorrhage from the gums is more rare. In several of the reported cases there was pain in the region of the spleen, probably due to perisplenitis. A number of cases have shown colic due to gallstones. Mackintosh, Falconer, and Anderson, in the autopsies of eight cases, found the liver normal or very slightly enlarged, with no cirrhotic changes and no obstruction of the bile ducts. In five of the cases there were gallstones. In all the cases the spleen was much enlarged, and in most there was evidence of a perisplenitis. The enlargement of the spleen was due mainly to increase of the pulp, which was enormously engorged with red cells. Three cases showed some splenic fibrosis. In all there was more or less deposit of pigment in the spleen, mainly within the endothelial cells. Most of the cases showed also a variable amount of pigment in the kidneys, and in two of the cases there was some fibrosis of the kidneys.

A hemolitic jaundice associated with diminished resistance of the red cells is pretty generally accepted, and all the essential features of the disease have been produced experimentally in rabbits.

Congenital family cholemia should be differentiated especially from hypertrophy of the liver, congenital obliteration of the bile ducts, obliterative cholangitis, inherited syphilis, and pernicious anemia.

Symptomatic Cholemia.—Cholemia may be caused by anything that interferes with the flow of bile. Such interference with the flow of bile may be caused by occlusion of the bile ducts through swelling of the mucous membrane of the ducts, the presence of inspissated mucus, the impaction of a gallstone, or by the pressure that may be caused by cancer of the stomach, liver, pancreas, omentum; or by sarcoma; or by the cicatrization of an ulcer in the duodenum or bile ducts, or by abdominal tumors, vertebral caries, aneurysm, etc.

Icterus (jaundice) appears in all grades of intensity. Usually itching, pruritus, is noticed after the jaundice has existed for some time, though it may be present before the appearance of the change of color. There may also be various cutaneous eruptions.

There is interference with intestinal digestion and absorption. Fat appears in the stools in large amounts. The feces are pale, from the presence of fat and the absence of bile. The absence of the normal stimulus of the bile upon the intestine results in lessened peristalsis and consequent constipation. The absence of the antiseptic action of the bile permits abnormal fermentation and putrefaction of the intestinal contents and causes meteorism. The secretions and excretions, urine, perspiration, milk, sometimes the sputum, may contain bile-pigments.

The presence of bile in the blood causes autointoxication. The pulse-rate is lowered (bradycardia), but in long-continued cases the pulse may be normal or quickened (tachycardia). Sometimes the pulse is irregular. The number of red blood cells is reduced, especially in the cases of long duration. The temperature is usually subnormal, unless elevated by some other cause than the cholemia. In long-standing cases it is not uncommon to have hemorrhages from the mucous membranes, especially epistaxia, gastrorrhagia, and enterorrhagia. The chief nervous symptoms that may occur are delirium, coma, convulsions, muscular tremors, and paralysis of the sphincters. A typhoid condition is not uncommon. Often there is a coated tongue, and some cases describe a bitter taste in the mouth.

The treatment of symptomatic cholemia should address the underlying cause, usually catarrh of the bile ducts, gallstones, syphilis, malaria, or carcinoma.

George E. Malsbary.

**Cholecystectomy, cholescystotomy.**—See *Gall-bladder.*

**Cholera, Asiatic.**—See The Appendix.

**Cholera Infantum.**—*Synonyms:* Gastroenteritis choleriformis, Choleraic diarrhea, Summer cholera, Acute milk infection.

Cholera infantum is an acute gastrointestinal catarrh affecting young children, characterized by large watery stools, profuse vomiting, high temperature, great prostration, and rapid wasting.

It is the most sudden and dangerous form of gastrointestinal inflammation to which children are liable, and is largely instrumental in causing the excessive infant mortality of the summer months. Cholera infantum is especially a disease of the crowded cities, but is not uncommon in sparsely settled country districts.

The custom, so general among physicians everywhere, of grouping all severe infantile diarrheas under the generic name of cholera infantum, leads to much confusion, and seriously vitiates the deductions drawn from compiled mortuary tables. The term cholera infantum should be strictly reserved for those comparatively rare instances of intense intoxication in which there are high temperature and frequent large watery stools with marked prostration.

The line of demarcation between cholera infantum and ordinary summer diarrhea, enterocolitis, cannot always be sharply drawn. Every epidemic exhibits cases which, beginning with distinct choleraic symptoms, soon subside into more or less protracted intestinal catarrh, and others in which the course of the latter disease is disturbed, perhaps abruptly ended, by an attack of infantile cholera.

But, although this is true, typical cholera infantum contrasts so strongly in symptomatology and fatality with all other forms of summer diarrhea as to entitle it to a separate chapter and a distinctive name. Little or no difficulty would be experienced if the term were rigidly restricted to the form of gastrointestinal inflammation outlined above.

Etiology.—Cholera infantum finds its analogue in Asiatic cholera. The clinical features of both point unmistakably to a bacterial origin, although no specific organism for the infantile disease has been yet discovered. Still evidences of a profound infection are too strong to be ignored.

Infancy, excessive atmospheric heat, improper feeding, and bad sanitary surroundings are all important factors in the causation. Except in occasional instances they are singly inoperative, but together they develop conditions under which the specific germs or toxins multiply and exert their deleterious influence on the heart, nerve centers, and intestinal vasomotor system.

Cholera infantum, as the name implies, is a disease of early childhood, and in the presence of favorable conditions the liability to its development is in direct proportion to the age of the infant.

It occurs more often during the first six months of infancy, and is rarely met with after the completion

of the first dentition. There is no ground for the belief that dentition is a factor in the causation, save that the great developmental and functional activity of the intestinal follicles during this period is a powerful predisposing cause to all kinds of intestinal derangement.

Cholera infantum is a disease of the summer months, and attains its greatest prevalence when the thermometer ranges the highest.

In the latitude of southern Ohio cases begin to appear in the latter part of May, attain their maximum prevalence and fatality in the months of July and August, and occur with varying frequency until October. High atmospheric heat exerts its deleterious influence by enervating the child's physical powers, by impregnating the air with the poisonous exhalations of decaying animal and vegetable matters, and by promoting the growth and distribution of toxicogenic germs.

Improper food is the cause of multiplied digestive disorders in the infant, but, except in the presence of summer heat, rarely, if ever, lights up a choleraic attack. Its close dependence upon an impure milk supply is well established. A few writers maintain that the cause is invariably in the food, and the poisons which induce the symptoms are not known to originate in any other food than milk or some milk preparation. Not infrequently a single improper meal will transform a mild diarrhea into the graver form of disease, and will sometimes develop an attack when the previous health was little disturbed.

Premature weaning, the use of commercial baby foods, and the American habit of admitting infants to the family table invite the disease. Hand-fed babies, however intelligently cared for, are prone to choleraic seizures, especially when exposed to the antihygienic surroundings, personal or domiciliary, of tenement life in the large cities. For obvious reasons the disease attains its greatest frequency and mortality among the children of the city poor and in foundling hospitals.

Morbid Anatomy.—The pathological lesions vary with the period at which death occurs, and are rarely as pronounced as the alarming character of the symptoms would indicate. In many cases which proceed rapidly to a fatal issue, the postmortem revelations are negative or at most only disclose a few patches of arborescent injection scattered over the intestinal mucous membrane.

In the more protracted cases, the lesions are better marked, and are those found in ordinary enterocolitis upon which the choleriform disease is so often engrafted. The mucous membrane is reddened, thickened, and softened, uniformly or in patches. The intestinal glands exhibit the most constant change. Both the patches of Peyer and the solitary glands are enlarged, and form translucent projections above the surface. Many of these enlarged glands soften, break down, and leave the mucous membrane more or less thickly studded with follicular ulcers. The mesenteric glands are congested. The brain is anemic and wasted, and serum is freely effused into the ventricles and on its surface. More or less hypostatic congestion of the posterior lobes of the lungs is nearly always observed.

Symptoms.—Cholera infantum usually begins abruptly with violent vomiting and purging, but may be proceded by a short and ill-defined prodromal stage.

In this latter event, anorexia, fever, fugitive abdominal pains and a few liquid stools, ordinary symptoms of an acute intestinal intoxication, precede, for a few hours or a day or two at most, the peculiar serous evacuations and nervous disturbances which give character to the attack.

It is a matter of common observation that the disease frequently occurs in the course of a diarrhea, more or less protracted, but, even in these cases, the distinctive choleraic symptoms begin suddenly and are sharply outlined.

The antecedent diarrhea unquestionably exerts a powerful influence in precipitating the attack, but it is not an essential feature of, nor can it be properly considered a preliminary stage of cholera infantum.

The stools first voided contain the contents of the intestines, milk curds, and particles of undigested food, mingled with intestinal mucus and liquid feces. The first stools are, as a rule, acid, later they are neutral and when serous they are alkaline. As long as fecal matters are present, the discharges have a peculiarly fetid and penetrating odor, which clings to the clothing and person after repeated washings. These discharges are soon replaced by large odorless stools, devoid of fecal matter, and so thin as to soak through the diapers like water, leaving only a greenish stain. The number of the stools varies. Ten, twenty, or more may be passed in the twenty-four hours; occasionally they recur at long intervals—two or three hours apart—but are so copious as to deluge the clothing and bedding. The discharges are quite irritating, and give rise to an erythema about the anus, which adds greatly to the child's discomfort. Under the microscope the stools show large numbers of epithelial cells, some leucocytes, and a profusion of bacteria of various kinds.

Abdominal pains and tenderness on pressure are usually not marked. Vomiting soon succeeds, or occurs simultaneously with, the intestinal discharges. It may precede them. It is nearly always persistent, and causes the immediate rejection of everything—food or drink—taken into the stomach. The stomach is speedily emptied of its contents, and afterward the ejected matters consist of the food taken, a greater or lesser quantity of serous fluid, the contents of the duodenum, and bile. Even should it subside the taking of drink or food provokes an immediate renewal.

The reaction of the vomited matter is at first acid, but subsequently becomes neutral or alkaline when the intestinal fluids and bile enter largely into its composition. The evacuations, both gastric and intestinal, take place suddenly, with little or no warning, and are ejected with considerable force.

The two symptoms just enumerated—free watery purging and vomiting—recurring simultaneously or in close succession, constitute prominent and distinctive features of cholera infantum.

The quantity of fluid discharged in a few hours through these channels is sometimes enormous. This excessive depletion necessarily causes rapid wasting and speedy exhaustion. Loss of weight takes place more rapidly than in any other disease of childhood. The child soon loses its plumpness, the muscles become soft and flabby, and the skin hangs in folds about the joints. The features become more and more pinched and drawn, and so changed as to seem unnatural. The child is extremely restless and moans continuously, not so much from pain as from thirst and the general ill-feeling which comes from rapid exhaustion.

Fever is present from the first. The surface may seem to the touch but little warmer or even cooler than natural, but measured by the thermometer in the rectum the temperature, in a case of ordinary severity, will range from 102° to 105° F. There are few diseases of infancy in which the temperature of the blood is higher, and occasionally a temperature of 105° F. to 108° F. will be registered by the thermometer when, to the touch, the skin is clammy and the extremities cold. The mouth soon becomes dry and glazed, and the lips deeply fissured. The tongue is dry and shining or coated with a brown fur. The loss of fluids causes intense thirst, and the little patient eagerly accepts the proffered breast or cup. Water and ice, if allowed, are taken greedily, though rejected by the stomach as soon as they are swallowed.

The secretion of urine is greatly diminished, and in the graver cases totally suppressed.

Cerebral complications develop in a large proportion of the severe cases. These are sometimes due, especially when the urinary secretion is scanty or suppressed, to uremic poisoning, but are more often attributable to that form of cerebral anemia which was first described by Marshall Hall under the name of spurious hydrocephalus. When this condition is imminent, the evacuations suddenly cease or recur at lengthened intervals. The fever disappears and the temperature sometimes drops below normal. The fontanelle, if unclosed, is deeply depressed, and, owing to the wasting of the brain tissue, the bones of the skull frequently overlap and render the surface of the cranium uneven. If the case does badly, the collapse deepens, the cerebral symptoms increase, the occiput is bored into the pillow, the eyelids remain half-open, the cornea is bleared, and the pupils are irresponsive to light. Coma, with or without convulsions, closes the scene. "We can hardly regard either the renal or the cerebral changes as an explanation of the nervous symptoms of most of these cases; they seem rather to depend upon impeded circulation due to a thickening of the blood, to acute inanition and general toxemia" (Holt). Convulsions occur in many of the fatal cases.

The duration of cholera infantum is short. Death may occur in eight or ten hours from the first disturbance. The mildest cases rarely last longer than three or four days by which time death ensues or convalescence is assured. An enterocolitis may indefinitely prolong convalescence or even cause a fatal termination long after the disappearance of the choleraic symptoms.

In those cases which pursue a favorable course, the first indication of improvement is the cessation of the vomiting. The child takes food and retains it; next, the diarrhea becomes less violent, and the fever abates. On the other hand, if the profuse flux from the gastro-intestinal tract is not arrested, fatal exhaustion necessarily results. In this event, the face grows more and more haggard and old-looking; the eyes are shrunken, bleared, and surrounded by dark rings; the surface is cold and cyanosed; the respiration sighing, and the pulse uncountable.

Prognosis.—The prognosis is grave. The frequency with which collapse and brain complications arise in cases apparently pursuing a favorable course, always justifies a guarded prognosis. Marked remissions in the symptoms occasionally occur, even in the later stages, and these lead to the building of false hopes by parents and friends. The duration of the disease is determined by the severity of the attack and the vigor of the child. It usually proceeds promptly to death or recovery. A constitution impaired by bad inheritance or previous illness, exposure to unhealthy surroundings, early age, and recent weaning, affect the prognosis unfavorably.

The mortality is greatest in children, under a year old, deprived of the breast.

The choleraic attacks which occur in the course of ordinary summer diarrheas are less amenable to treatment than those which have developed in rugged health.

The occurrence of collapse, or the hydrencephaloid condition, unless promptly relieved, renders the outlook hopeless.

Death occurs from exhaustion or cerebral effusion. Edema of the lungs, due to failure of the heart, often hastens the fatal termination.

Diagnosis.—The diagnosis is easily made. In fact, there is no disease for which it can be mistaken.

The severe serous vomiting and purging, the high fever, the rapid wasting and exhaustion, stamp it with an individuality which almost precludes the possibility of error.

Treatment.—Every case of true cholera infantum should be looked upon by the medical attendant as an emergency case. It is essentially an acute poisoning, in which exhaustion often comes so quickly that intelligent interference is demanded and demanded promptly.

In the way of prophylaxis the importance of suitable food, good nursing, and proper hygienic surroundings can scarcely be overstated.

During the hot months the most scrupulous cleanliness of person, clothing, nursing bottle, and everything about the infant must be observed.

No case of summer diarrhea in a hand-fed infant should ever be ignored. Special emphasis should be put upon this axiom, as the writer is thoroughly in accord with those who hold that the choleraic symptoms are almost always preceded by some gastro-intestinal derangement.

When the attack develops the coolest and best-ventilated room in the house should be chosen for the patient. It should be darkened and all noises and sources of irritation suppressed.

The first, and an imperative indication, is to assist nature in her efforts to remove the poison from the alimentary tract. There is no time to await the action of the traditional purge, if the stomach did not promptly resent its administration, and emetics are inadmissible. This indication is best fulfilled by lavage of the stomach and enteroclysis. The former rarely fails to lessen or stop the vomiting, and should be employed whenever this symptom is violent and distressing. The stomach should be thoroughly washed with warm, sterilized salt or soda water until the fluid returns clear. Ordinarily a quart will be needed. Oftentimes one thorough cleansing will suffice, but in obstinate cases it may be repeated several times.

The flushing of the stomach should be followed by small doses of calomel (gr. $\frac{1}{10}$) dropped on the tongue every half-hour until from one to two grains are taken, or until the stools show green.

Thorough irrigation of the colon is of the utmost importance. It should be begun early in the attack and repeated two or more times daily until convalescence is well established.

A flexible tube should be introduced without force, high into the colon and from one to three quarts of water used at a sitting, allowing it to flow in and out freely. The escape of the water may be facilitated by passing a second catheter through the sphincter. To be effective the water must find access to the whole of the large intestine. This douching should be immediately followed, after the method of Professor Cantani, by an equally large quantity of a warm tannin solution (gr. xx. to a pint). The object of the tannic-acid irrigation is to render inert any soluble poisonous proteins which may remain after the first washing.

All irrigations should be given slowly, and to prevent undue pressure the water supply should not be raised over two or three feet above the body of the patient.

The child must not be overfed. The intense thirst leads to the eager taking of everything which the mistaken kindness of mother or nurse may proffer. Healthy breast milk should be supplied when practicable. Cow's milk in every form or preparation should be positively prohibited until the brunt of the attack is over. The same may be said of proprietary baby foods. Not infrequently it will be advisable to cut off all foods, even breast milk, for the first ten to twelve hours. If this is not deemed judicious, or when feeding is resumed, small quantities of a thin rice or barley water alone, or into which has been strained the white of an egg and seasoned with salt may be given. Later on, animal broths, beef juice, or whey may be added to the dietary, and, still later, peptonized milk and the malted foods.

To relieve the thirst, water may be given freely but in small quantities at a time, or the child may be permitted to suck pieces of ice wrapped in a napkin. A very weak tea, or water acidulated with phosphoric or hydrochloric acid, is both grateful and beneficial. In severe cases it is not possible to replace the excessive intestinal drain with mouth-given fluids. The indication is, however, fully met by hypodermoclysis.

A saline solution (sodium chloride, gr. xlv. to the pint), warmed (110° F.) and sterilized should be slowly injected into the cellular tissue of the thigh or buttocks. At least one-half a pint should be used at a time. From one to two pints may be given every twenty-four hours.

There is no one remedy in our experience so generally useful as opium, although its use is condemned by excellent practitioners. It should always be given alone: in this way the dose and frequency of administration can be readily changed without interfering with other remedies.

The hypodermic method is, by odds, the most eligible method of administration. To a child one year old may be given morphine gr. $\frac{1}{100}$ to gr. $\frac{1}{50}$ combined with atropine gr. $\frac{1}{800}$ to gr. $\frac{1}{600}$. It is better to use the smaller doses and repeat carefully in from one to three hours until there is cessation or diminution in the discharges and improvement in the heart's action and in the nervous symptoms. It should be carefully watched and withheld on the appearance of cerebral complications. If the vomiting is not too severe the deodorized tincture of opium (♏ i.) or paregoric (♏ x. to xxx.) is a good substitute.

When the violence of the vomiting has abated recourse may be had to the so-called intestinal antiseptics. Sodium salicylate (gr. i.); salol (gr. ss.); creosote (♏ $\frac{1}{4}$–$\frac{1}{2}$); resorcin (gr. $\frac{1}{4}$) and many other drugs are commended by authors. The writer has been accustomed to rely with the most confidence on the bismuth preparations, of which the subnitrate (gr. x.) and the subgallate (gr. ij.–iij.) are the best.

I have seen good results from the aromatic sulphuric acid (♏ iij.) given in a teaspoonful of bitter almond water.

French authors speak highly of the nitrate of silver. It may be given by the mouth (gr. $\frac{1}{12}$–$\frac{1}{8}$) or the rectum. When used by rectal injection the anus should be first washed with a solution of common salt, as otherwise even weak solutions may cause severe tenesmus. The hyperpyrexia, which is in itself an element of danger, and the attendant nervous phenomena are best treated by repeated cold sponging or the graduated bath. The use of antipyretic drugs, especially the coal-tar derivatives, cannot be too strongly condemned.

For the bath the child is gently immersed in water at 100° F. when the temperature is gradually reduced by the addition of cold water or ice to 85° F. An ice cap should be worn on the head. The immersion is continued for from ten to fifteen minutes and should be repeated whenever the temperature approaches the danger line. It is inadmissable should symptoms of exhaustion or collapse be present.

Stimulants are needed in nearly all cases. It is a common mistake to delay their use too long. If not retained by the stomach they should be given hypodermically and per rectum.

Good old whiskey in gtt. x. to xxx. doses, repeated as required, fulfils every indication. It is surprising how much whiskey can be profitably taken by a child threatened with collapse.

Strychnine nitrate (gr. $\frac{1}{30}$) and atropine sulphate (gr. $\frac{1}{800}$) given hypodermically will often carry a flagging heart over a critical period.

During convalescence the child should be carefully watched, as one attack increases the liability of a recurrence.

W. J. Conklin.

**Cholera Nostras.**—This is an acute gastroenteritis, with diarrhea, cramp, and vomiting. It bears the same relation to ordinary cases of enteritis in adults as cholera infantum bears to enterocolitis in infants or small children. The disease may attack a portion of the bowel, setting up a duodenitis, jejunitis, ileitis, sigmoiditis, or proctitis, or the whole gastrointestinal tract may be involved. In rare instances the inflammation may be confined to the large intestine.

*Synonyms.*—Cholera morbus, enteritis acuta, catarrhus intestinalis acutus, acute diarrhea, acute intestinal catarrh. It is also sometimes embraced under that very comprehensive term "acute indigestion."

Etiology.—This form of gastroenteritis is most frequently observed in the summer months, and is in the majority of instances traceable to some error or indiscretion of diet. In some people there exist idiosyncrasies toward certain articles, and the ingestion of these articles is followed by an attack of this acute malady. The eating of shell fish, fish that has been rather long out of the water, unripe or tainted fruit, canned goods of uncertain "pedigree," a miscellaneous mixture of various indigestible substances, combined with the drinking of ice water, beer, or other fermentable liquids, frequently occasions this disorder. It is quite probable that bacterial infection plays an important part in the etiology, although no particular organism has been isolated as the sole etiological malefactor. In some cases, preformed products of the food are active; in other cases it is probable that, as a result of digestive disturbance after dietetic indiscretions, bacterial decomposition in the stomach or intestinal tract quickly follows.

Chilling of the body after a hearty meal is an important etiological influence. Even the laity have noted the danger of permitting the exposure of the body to a cool draught or the chilling influence of the night air after filling the stomach with a liberal amount of food and drink.

Mechanical or chemical irritants may also set up a train of symptoms that to all intents and purposes constitutes an attack of cholera nostras.

Morbid Anatomy.—This depends greatly on the course of the disease, especially the duration. The entire gastrointestinal tract may be involved, or only isolated portions of the intestines. These differences depend on the cause and intensity of the inflammation, and the extent of the catarrhal process. We might say that the actual anatomical changes are fairly commensurate with the severity of the symptoms, which is decidedly different from some other gastrointestinal diseases.

The mucous membrane of the intestines is reddened uniformly or in spots, from light red to dark purple in color, especially marked around the follicles and plaques, on the summit of the valvulæ conniventes and of the villi. If the inflammatory process is intense, extravasations of blood occur, the mucous membrane is swollen and edematous, and is often covered with tenacious mucus, stained by bile or blood, and more or less opaque. Desquamated epithelial cells and occasionally a few pus cells are seen in the mucus under the microscope, while layers of epithelium may desquamate and form gray shreds. The fecal contents are usually liquid. The villi and solitary follicles are swollen, and appear as whitish nodules surrounded by a red injected area. Should the process continue, these nodules may rupture and develop follicular ulcers. The catarrhal ulcers are produced by loss of the epithelial covering and extension of the inflammation. Irritation in the neighborhood of these ulcers may in protracted cases give rise to polypoid growths.

Microscopically, there are congestion and distention of the blood-vessels of the mucosa and sub-

mucosa, and small extravasations are at times seen between the glands of Lieberkühn. The spaces between these glands are frequently widened, and contain abundant masses of round cells. These cells may also be present in the superficial or deeper layers of the submucosa. The epithelium is certainly involved in the catarrhal process, as degenerated epithelial cells are found in the mucus along with the stool. The crypts of the glands may be cloudy and swollen. (Kemp.)

Symptoms.—These depend on the etiology, the location in the alimentary tract where the first morbid changes occur, and the apparent severity of the attack. The onset frequently occurs in the middle or latter hours of the night, and is usually sudden and violent, beginning with nausea, intense and explosive vomiting, and exeruciating abdominal pain and cramps. The contents of the stomach are quickly evacuated, after which bilious vomiting takes place. When there is nothing left to vomit, intense and agonizing retching ensues, which convulses the unfortunate sufferer from center to circumference.

Either simultaneously or soon after, diarrhea begins. First come one or more copious fecal movements, speedily followed by huge watery discharges, which emerge without expulsive effort, are accompanied by no tenesmus, and may finally become almost or quite involuntary. This tendency to large and frequent watery movements, minus tenesmus, with the involuntary feature, is a marked characteristic of cholera nostras.

Along with this violent vomiting and purging comes a quick and marked prostration, so that the patient often in his efforts to go to or from stool falls fainting upon the floor. Some of these sufferers, caught alone in this plight, almost die before help can be summoned, and their bodily weakness in the presence of the violent fluid evacuations from both exits of the alimentary canal causes them to present a both sorry and pathetic spectacle.

The abdomen is tender, sometimes excessively so. At first the patient lies upon the side, with legs flexed to relieve pressure, or upon the back with the thighs acutely flexed upon the body. Later on, as prostration ensues, the pain becomes less noticeable, and the main desire is to be left alone.

At the onset the temperature frequently rises, sometimes to the point of hyperpyrexia. Later, as prostration ensues, the surface temperature falls, and the extremities, the face, or the whole body may become cold and clammy. The rectal temperature, however, may remain high, even in the presence of extreme prostration, and in fatal cases, may remain so until the end. The secretions, especially the urine, become scanty, following the great loss of body fluids by the bowel. Albumin and casts are generally in evidence.

In severe cases the collapse is so sudden and overpowering, that the condition can hardly be distinguished from true Asiatic cholera. The general appearance of the sufferer is most melancholy, the face being cold and cyanotic, the lips dry, the tongue parched, the breath devoid of warmth, respirations feeble, pulse weak and thready, and the general condition that of deep collapse. A rather remarkable feature is the sudden "ageing" in appearance, brought on by the drain of fluid from the tissues. The writer well remembers the instance of a ruddy-faced youth, who, after six hours of what proved to be a fatal case of cholera nostras, presented the wrinkled visage of an octogenarian.

In mild cases, or in those with strong recuperative power, there sometimes ensues after a brief but stormy period a sudden amelioration of all the symptoms, followed by complete recovery in one or two days. This fortunate state of affairs is rather infrequent, however, as in most patients afflicted with this depressing malady, the prostration remains to some extent for several days or weeks.

Diagnosis.—The recognition of this disease is generally easy. The history, onset, abdominal pain, vomiting, and diarrhea, associated with the other symptoms above-mentioned usually suffice to stamp it beyond a doubt. When the trouble is mostly in the large intestine, it is sometimes difficult to decide whether the enteritis is of the ordinary type or dysenteric. In mooted cases, a bacteriologic examination may be required to clear up the diagnosis.

Stengel notes an occasional puzzling resemblance to typhoid fever, mentioning continued fever, diarrhea, prostration, loss of appetite, coated tongue, and headache. The writer is forced to confess that no cases under his observation have presented this diagnostic difficulty, the various cases of typhoid fever and cholera nostras having shown symptoms almost as diverse as the poles.

The principal disease from which it needs to be differentiated is Asiatic cholera, and in times of epidemic of this specific ailment, it is wise to look upon all acute gastrointestinal disturbances with suspicion. It is well known that mild cases of true Asiatic cholera are often seen in times of epidemic prevalence of that disease, and during such times it is best to regard all choleraic diarrheas as specific, unless there is a strong reason to the contrary.

Prognosis.—The prognosis of ordinary cases of cholera morbus in adults of average strength is usually favorable. Unless the disease is of very severe type or is complicated by other exhausting ailments, recovery may be confidently anticipated. After one to three days of apparently dangerous illness, a subsidence of all painful symptoms appears, followed by more or less prompt restoration to health. Occasionally only does cholera nostras develop a subacute, or even a chronic, intestinal disorder; it is essentially an acute condition, and generally when the acute symptoms have departed, only natural recuperation stands between illness and health. In the aged or infirm the prognosis should be guarded.

Prophylaxis.—This consists in temperate eating, especially in hot weather, and the avoidance of any or all articles that are prone to disagree. Heavy evening meals, followed by exposure to chilling draughts are dangerous, and particularly should chilling influences be warded off the abdomen. In tropical countries the wearing of abdominal bands is quite common, and in any clime is a wise precaution for susceptible individuals.

All that make for pure food, wholesome water, and guarded indulgence in the pleasures of the table may be considered as appropriate prophylactic measures in preventing this most alarming malady.

Treatment.—As in any other fulminating diseases, the treatment must be prompt and energetic. This disorder occasions many of the urgent night calls that force the often weary physician from his bed, and the admonition, "wait until morning" is met by frenzied appeals for immediate aid. Cholera nostras brooks neither delay nor therapeutic dalliance.

Emetics are never needed, as the stomach is empty by the time medical help is at hand. The same may be usually said concerning cathartics. The indications are to ease the intense cramps, to quiet the convulsive vomiting, to sooth the almost volcanic peristalsis of the intestines, and to sustain and stimulate the rapidly flagging strength. Morphine should be at once administered, and hypodermically, for the stomach is generally in no condition either to retain or to absorb it. With the first hypodermic injection of morphine it is well to include one seventy-fifth grain of atropine, to check some of the serous exudate from the intestines. The morphine may be repeated in half an

hour, if the symptoms are not abated, but the single dose of atropine is generally sufficient.

If the stomach will possibly retain it, frequent doses of capsicum and ginger are both quieting and efficacious. To this may be added a small amount of chloroform and laudanum, though the latter is sometimes not well borne. It seems that in this acute state medicaments that are *hot* have the best effect, and, if they are but slightly diluted they will more often be retained.

Another point of value lies in small doses frequently repeated. It is much better to give a few drops of the medicament, diluted in one or two spoonfuls of water, frequently, than to give a larger amount at longer intervals. This frequent dosage is not only intrinsically of worth but also reassures the perturbed and suffering patient, who desires, and clamors for, speedy relief.

Should the stomach be absolutely intolerant, starch enemas, each containing twenty to thirty drops of laudanum, may be injected at half-hour intervals. The physician, however, must be on the lookout for signs of narcosis. Tablespoonful doses of brandy or whiskey may be appropriately added to these injections.

For the prostration and chilliness, brandy or whiskey may be given by the mouth, if the stomach will retain it. Hot applications to the abdomen, accompanied by hot-water bags or hot wrappings to the body and extremities are often indicated. In addition to surface heat to the abdomen, counterirritants, such as chloroform, mustard, turpentine, or capsicum will also be of service, being useful in both the reduction of cramps and warming the body surface.

The heart's action should be watched, and, if necessary, diffusible stimulants should be freely administered, either by the mouth or subcutaneously. Occasionally subcutaneous injections of liberal amounts of physiological saline solution will exert a most beneficent effect on the thready pulse and the desiccated tissues.

After the more urgent symptoms have subsided, the patient will be weak from the ordeal of pain and diarrhea and vomiting, and sore from the last. This soreness can be promptly relieved by the internal administration of turpentine emulsion, six drops to the teaspoonful, and given four or five times daily. The application of turpentine stupes to the abdomen will also aid in dissipating the soreness.

The convalescence may be managed in this disorder as in other acute irritations of the gastrointestinal tract, care being taken to avoid indigestible foods or those rich in cellulose for quite a time after the active symptoms have abated. Should the appetite lag, the simple stomachics may be given before meals, plus small doses of dilute hydrochloric acid after the meals.

Should the convalescence be halting, a change, if practicable, to a cool and pleasant environment will nearly always expedite recovery.

One caution in regard to aged people may not be amiss. Endeavor to control the acute symptoms with a minimum of opiates, and keep up the stimulation for some time after reaction has seemingly set in.

Cholera nostras, though one of the most acute and dramatic of gastrointestinal disorders, can, by energetic treatment, be controlled in probably ninety-five per cent. of uncomplicated cases, and in no disease can the physician obtain more prompt response to appropriate and well-considered therapeutics.

GEORGE M. NILES.

**Cholesteatoma** ("pearl-tumor") is the term applied to spherical tumor-like formations having a connective-tissue capsule lined with squamous epithelial cells and enclosing a yellowish-white, grayish, or bluish-white mass of horny scales arrayed in concentric laminated strata having a pearly or satiny sheen. The included pearl may be firm, or pultaceous and crumbling in consistence; or drying, it may separate into distinct horny layers or scales or form a dry flaky powder. The central portion of the pearl may sometimes contain fluid. Cholesterin crystals are often present in the pultaceous contents; hair is occasionally included. The pearls may range in size from a pinhead to a hen's egg. They may be single or multiple. The microscopic examination shows always an epidermoidal or dermoidal structure. The pearl represents dead and desquamated horny cells packed by pressure into a firm onion-like sphere, the layers of cells appearing in microscopic sections as non-nucleated fibrillæ. Next to the connective-tissue capsule will always be found a layer of squamous epithelium, usually in a single layer, and often atrophic, the cells being very thin. The epithelium may be absent in portions of the wall; or in large and old cysts it may be entirely absent. In such cases the epithelial pearl may be surrounded in part or wholly by an inflammatory zone containing numerous foreign-body giant-cells. In some cases the cholesteatoma may be invaded by foreign-body giant-cells that surround the cholesterin crystals and horny scales, or hairs should the latter happen to be present. In the latter case the connective-tissue capsule contains hair-follicles, sebaceous and sweat glands (dermoid cyst).

From their structure the cholesteatomas must be classed with *epithelial* formations, either *epidermoidal* or *dermoidal*. Virchow regarded them as of connective-tissue origin, and some writers at the present time think they may be in part derived from endothelium, but the present tendency is to look upon them as wholly epithelial in origin. Following Boström the writer accepts this view; he has never seen a cholesteatoma in which the epithelial nature could not be easily shown. The epidermoidal origin is also shown by the presence of keratohyalin and eleidin.

OCCURRENCE.—Cholesteatomas are found in the inner meninges of the brain, more rarely of the spinal cord, in the middle ear, mastoid antrum, Eustachian tube, external auditory canal, accessory sinuses, salivary glands, eye, mouth, tonsils, urinary passages (pelvis of kidney, ureters, bladder, urethra), uterus, ovary, testis, gall-bladder, mamma, and dilated bronchi. They may appear as independent tumor-like formations, but in the great majority of cases *they are associated with chronic inflammations.* This is practically true of all cholesteatomas except those of the nervous system and sexual glands, and certain of the fissural dermoids and epidermoids. It is evident that they may arise in different ways. The cholesteatomas of the central nervous system and sexual glands, and very rarely of other regions of the body are *teratoid epidermal* and *dermal inclusions;* all others are *traumatic* or *inflammatory inclusions of epithelium that undergoes a horny change.* Cholesteatomas may, therefore, be classed as *teratoid* and *inflammatory.*

1. TERATOID CHOLESTEATOMAS.—The typical ones are those of the cerebral meninges and choroid plexus. They are found most frequently at the base of the brain in the neighborhood of the olfactory lobes, tuber cinereum, optic commissure, corpus callosum, in the ventricles, pons, medulla, and cerebellum. They are usually connected with the meninges, but may be found in the cranial bones. They are much more rare in the meninges of the cord. In several cases reported multiple cholesteatomas of brain and cord were observed. They appear as satiny shining nodules, usually about the size of a pea, more or less deeply imbedded in the brain substance. When of large size they may erode the cranial bones or cause perforations. They cause pressure changes, atrophy and increase of neuroglia, in the neighboring brain tissue. Their effects are purely mechanical. The tumor nodules are usually single, but portions of the cholesteatoma may become displaced into the surrounding brain

tissue. As Boström has shown, it is always possible to demonstrate at some point a connection between the cholesteatoma and the pia at a point where epithelial cells form a layer upon a basement membrane of vascular connective tissue, the cells of this layer being continuous with the scales of the cholesteatoma. Usually the layer of epithelial cells does not extend entirely around the pearly mass; a large portion of the latter may be uncovered or lie in direct contact with the brain substance. The origin of the cholesteatomas of the nervous system is to be referred to an aberrant displacement of epidermoid or dermoid anlage into the anlage of the meninges during an early period of development (fourth to fifth week) of the brain. Likewise, the cholesteatomas of the cranial bones arise from aberrant ectodermal cells included in the vascular marrow where they continue to grow. The cholesteatomas of the *sexual glands* are simply dermoid and epidermoid cysts of these organs containing pearly masses of dead horny cells. Their origin and significance are the same as in the case of those tumors. It is probable that in rare cases cholesteatomas of other regions of the body (ear, lumbar and sacral regions, etc.) are also derived from ectodermal cells displaced during the period of embryonic development. Some of the *fissural epidermoids* and *dermoids* of the skin (branchial, etc.) appear as pearly tumors.

2. Inflammatory Cholesteatomas.—In chronic inflammations of the *middle ear* fungoid masses of granulation tissue are often seen containing small pearls of squamous cells. The squamous cells may be derived from an ingrowth of the epithelium of the external auditory canal through perforations of the drum, or as a result of a metaplasia of the epithelium of the middle ear. Such cholesteatomatous polypi may erode the neighboring bone. Likewise, in the *urinary passages* inflammatory hyperplasias of the mucous membranes with epidermoidal metaplasia and cornification of the epithelium give rise to cholesteatoma-like formations. Similar formations are found in the *uterus, gall-bladder, mamma, tonsils, mouth*, etc., as a result of inflammatory hyperplasias associated with a metaplasia of the epithelium. They may be found rarely in *bronchiectatic cavities*. In the *skin, conjunctiva*, and *mucous membrane of the mouth* traumatic or surgical inclusions of epithelium may give rise to *inclusion cysts* of a cholesteatoma-like character. They occur particularly after penetrating wounds in which epidermal cells are displaced into the deeper tissues. These rarely take on the character of neoplasms.

While the changes produced directly by the cholesteatoma are usually those due to pressure, a squamous-celled carcinoma may develop from such an epithelial inclusion. In the case of the papillomatous cornifications associated with chronic inflammations, as in the pelvis of the kidney, gall-bladder, etc., a horny cancer may develop on such a cholesteatomatous base.

Aldred Scott Warthin.

**Cholesterin, Cholesterol** ($C_{27}H_{46}O$) is a monatomic unsaturated alcohol; a complex terpene, grouped with the lipoids, but differing in constitution from the fats, carbohydrates, and proteins, and is found in all of the body tissues, either free or in combination with fatty acids. Related bodies (stearins) are found in the sebaceous secretions and wool-fat of many animals. The older term cholesterin is now almost wholly withdrawn from the literature of the day in favor of cholesterol. Although the latter term indicates its chemical position as an alcohol, much confusion has arisen from the freakish abandonment of the old term, and we see some writers using the two terms as if they indicated different substances. As its name indicates, this substance was first recognized as a constituent of the bile and was regarded as a bile fat (cholestearin); but its proper designation is cholesterin (bile solid). When pure it crystallizes in white mother-of-pearl leaflets which have a fatty feel but possess no taste or odor. It has a neutral reaction, melts at 146–147° C., and sublimes without change in a vacuum at 360° C.

Cholesterin is insoluble in water, dilute acids, dilute and concentrated caustic alkalies, and in cold alcohol. It is soluble in hot alcohol, ether, chloroform, benzol, and in the volatile fatty oils; but dissolves with difficulty in solutions of the bile-acid salts, and is only slightly soluble in water solutions of soaps. The solution in ether is neutral, and turns the polarized ray of light to the left.

From ether solutions cholesterin crystallizes on evaporation in large, thin, transparent, rhombic plates ($C_{26}H_{44}O+H_2O$), whose edges and corners are frequently irregularly notched, so that the plates as they lie heaped up have the appearance of being cut out in step-like forms. The formation of the plates is frequently preceded by a stage of fine needles which gradually change into blunt cones and then pass into the plate form. Cholesterin is unchanged by the action of boiling caustic alkalies. With concentrated nitric acid it yields cholesteric acid ($C_{12}H_{16}O_7$) in addition to acetic and butyric acids. Concentrated sulphuric acid gives cholesterin a red color, and breaks it up into a variety of isomeric hydrocarbons (cholesterilin). When heated with organic acids for long periods of time at 200° C. cholesterin passes into ether combinations: as for example with acetic acid it forms acetic-acid-cholesterin-ether ($C_{26}H_{43}C_2H_3O,O$).

When treated with a mixture of five parts concentrated sulphuric acid and one part water, cholesterin crystals take on a deep carmine red which gradually passes into violet (Salkowski's test). A weaker solution causes a violet coloration of the edges of the crystals which on the addition of water becomes lilac. Sulphuric acid containing a trace of iodine colors the crystals violet, blue, green, and red.

If cholesterin is dissolved in chloroform in a dry test-tube, and acetic acid anhydride added, the addition of concentrated sulphuric acid, drop by drop, produces a rose color which quickly becomes blue and after a few minutes changes to vivid green (Liebermann-Burchard test). When only very small amounts of cholesterin are present the green color alone appears. This is one of the most reliable tests for this substance, and the presence of 0.05 milligrams can be shown by it. When substances containing a small amount of cholesterin are evaporated with a drop of concentrated nitric acid upon the water bath, a yellow coating is left, which on the addition of ammonia becomes bright red.

Cholesterin is a constant constituent of the bile of all animals, in which it is held in solution by the bile-acid salts and the soaps. The proportion in normal human bile is about two per cent. of the total solids. It is also found in the intestinal contents as a result of the presence of bile. It is rarely formed in the urine. In the blood it occurs only in a very small amount, which is held in solution by the fats and soaps of the blood. The various nerve structures contain it in large proportion; more than half of the dry substance of nerve fibers consists of fat and cholesterin; the dried corpus callosum contains as much as fifteen per cent. of cholesterin, the whole brain dried 2.3 per cent., dried human liver 5.9 per cent., and dried muscle 0.5 per cent. Under ordinary conditions it cannot be recognized in the tissues or secretions, but in certain pathological conditions its characteristic rhomboid plates are found. Burchard has found traces of cholesterin in every organ and tissue of the body. It is represented in plants by the closely related *phytosterins*, paracholesterins and kaulosterins. From its wide distribution cholesterin may be said to be a constant if not a primary constituent of the animal cell.

Under certain pathological conditions the cholesterin of the bile may be separated, giving rise to the formation of calculi, which consist largely or entirely of cholesterin (ninety-five per cent.) or of cholesterin in connection with bile pigment, phosphates, carbonates, etc. An ethereal extract of the crushed calculi will yield cholesterin crystals on evaporation. The tests mentioned above may be applied to the extract. Cholesterin stones are usually single, oval stones, yellowish and waxy in appearance. On fracture they show a radiate crystalline structure. Small cholesterin bile-stones may have the appearance of pearls when moist, but become dull when dry.

Cholesterin is also found in old exudates and in the contents of cysts, especially in ovarian and hydrocele fluids. In these it may occur in so great an amount that the crystals may be seen with the naked eye as small shining particles. It may be found also in the fatty changes occurring in atheromatous conditions of the blood-vessels, wens, cholesteatomata, caseating tubercles, old abscesses, old hemorrhages, and degenerating tumors. It is a constant constituent of pus, probably arising from the fatty degeneration of the leucocytes. Cholesterin crystals are also found in echinococcus cysts, and rarely in cataractous lenses. As the process of imbedding usually dissolves out the cholesterin, the position of the cystals is indicated by clefts or narrow diamond-shaped spaces ("cholesterin-clefts"). Foreign-body giant-cells often surround cholesterin plates, so that the cholesterin-clefts often appear within giant-cells (old abscesses, hemorrhages, tubercles, etc.).

The part played by cholesterin in the animal economy is practically unknown, as is its origin and ultimate fate. Its widespread occurrence would indicate its importance. We also know but little concerning the conditions under which it exists in the cells, whether simply dissolved in the fats or soaps, or held in loose combination with them, or more firmly combined with the fatty acids as cholesterin-esters. A number of investigators claim to have demonstrated the presence of cholesterin-esters in normal blood. Cholesterin has also been shown to be a constituent of the doubly refractive myelin bodies, and Aschoff believes that these are a compound of cholesterin and fats (cholesterin-esters) rather than a solution or loose association of them. It is probable that combined with other lipoids the cholesterins promote the absorption of fluid and enable the fats to assume a diffuse form rather han that of discrete globules. Saturated combinations, isocholesterin and coprosterin (probably a dihydro-cholesterol) occur in the skin glands and intestinal contents respectively. Horse feces contain hippocoprosterol. It had been supposed that the coprosterols represent reduction products of the cholesterin of the bile, due to bacterial action, but recent work indicates that they are derived from the diet. It has also been assumed that a part of the cholesterin of the bile is reabsorbed while a part is excreted as coprosterin. The origin of the biliary cholesterin is unknown; studies so far made would indicate that it may be in part formed by the liver cells, or in part from the epithelium of the gall-bladder. In normal bile the cholesterin is supposed to be in a state of colloidal suspension (Lichtwitz), not as pure cholesterin but as a lipoid compound of cholesterin and oleic acid (cholesteryl oleate). Under certain conditions the fatty acid is liberated and the cholesterin precipitated in a crystalline form around a nucleus of epithelial cells, mucus, or bacteria. Cholesterin inhibits saponin hemolysis, and also inhibits the activation of cobra venom by lecithin (Kyes and Sachs). Cholesterin also inhibits the hemolytic action of ankylostomum extract. According to Meyer the resistance of red corpuscles to saponin hemolysis is in direct relation to the amount of cholesterin they contain compared with lecithin. Acting upon these observations, Reicher has used cholesterin in the treatment of pernicious anemia and reports good results.

When our knowledge concerning the function of cholesterin is summed up, it seems highly probable that this substance plays the rôle of a protective substance in increasing the resistance of the body to infections. ALDRED SCOTT WARTHIN.

**Cholic Acid,** $C_{24}H_{40}O_5$, is found in the intestine as a decomposition product of bile. In bile it occurs in the form of conjugate acids—the bile acids—glycocholic and taurocholic acid. F. P. U.

**Choline.**—Trimethyl oxyethylammonium hydroxide, or choline, $N\langle^{(CH_3)_3}_{OH}\rangle CH_2.CH_2.OH$, occurs both in the plant and animal kingdoms. It stands in close relationship to the poisonous base neurine which can be formed from choline by bacteria, and also to muscarine which is the aldehyde of choline, while betaine may be looked upon as the anhydride of the acid corresponding to choline. In the animal organism choline is undoubtedly derived from lecithin. Great importance has been attached to choline from the fact that it has a marked depressant action upon blood pressure; that in this respect it is antagonistic to epinephrine; that it has an excitatory influence upon the secretion of certain glands, and that in degenerative conditions of the nervous system it has been found in the blood. It is a substance which decomposes very readily, yielding among other compounds, trimethylamine. See also *Ptomaines.*

FRANK P. UNDERHILL.

**Chondrodystrophy.**—See *Nanism.*

**Chondroitin.**—See *Chondromucoid.*

**Chondroma, Chondroblastoma.**—A neoplasm consisting essentially of cartilage is known as a *chondroma* or *chondroblastoma.* Chondromas occur usually as spherical, nodular, tuberous, knobbed, or lobulated growths, sharply circumscribed, of a firm consistency, and an opalescent, milky, semi-translucent surface. They may be single or multiple, and may reach a large size. The small ones are usually spherical; the larger ones lobulated. They arise chiefly from the *perichondrium, periosteum,* and *endosteum;* but also occur in soft tissues containing no cartilage, and in certain internal organs (salivary glands, testis, lungs, etc.). The majority of the cartilaginous tumors not connected with the skeleton represent disturbances of development or form part of mixed teratoid tumors of complicated structure. The chondromas arising from the skeleton are often called *ecchondroses* or *cartilaginous exostoses;* those not associated with bone or cartilage are known as *enchondromas,* although the latter term is applied by many writers to all varieties of chondroma.

MICROSCOPIC STRUCTURE.—The microscopic picture varies greatly; a chondroma may present the characteristics of hyaline cartilage, or less frequently that of reticular or fibrous cartilage. All forms of normal cartilage may be found in these neoplasms, frequently in the same tumor. Very often the cartilage resembles embryonic cartilage. Fine fibrillæ are always found in the hyaline matrix, and elastic fibers are also usually present, especially in the chondromas of the internal organs. The fibrillæ of the ground substance are connected with those of the connective-tissue capsule and trabeculæ; radiating systems of fibrillæ with cells as their centers are found throughout the ground substance. In the majority of cases the chondroma is divided into islands of cartilage separated

by trabeculæ of connective tissue containing blood-vessels; these trabeculæ are continuous with the capsule which forms a sort of perichondrium to the growth as a whole. The cells of chondromas vary greatly as to their number, size, form, grouping, and development of capsules. Some chondromas are very cellular; others are poor in cells; in some the cells are very large, in others they are small, while still others show both large and small cells. The cells are round, spindle, or stellate. The cells may be enclosed in the so-called capsule, or the latter may be absent; sometimes groups of cells are surrounded by a capsule. The greater the number of cells and the more atypical their character the greater is the tendency of the chondroma to malignant growth.

Degenerative changes are very common in the chondroma, both in the cells and in the ground substance. Mucoid change is by far the most common, the majority of chondromas showing it to a greater or lesser extent, so that they are frequently classed as *myxochondromas* (*chondroma myxomatodes*). As the mucoid degeneration advances in the ground substance, the cells often take on a radial arrangement; when the cell-protoplasm is involved in the mucoid change the cells themselves take on a radial or stellate appearance. With hematoxylin and eosin the myxochondroma matrix stains intensely blue, while the cartilage cells and capsules often make an intense eosin. With the metachromatic stains for mucin the characteristic reactions may be seen both in the ground substance and in the cells. *Liquefaction necrosis* is also common in the larger and older chondroma masses, giving rise to irregular clefts and cavities (*chondroma cysticum*). Both ground substance and cells may be destroyed, and large degeneration cysts are often formed in this way. *Hyaline degeneration* of the connective-tissue of the capsule and trabeculæ is also of common occurrence; *osteoid* formations are not rare (*osteoid-chondroma*). *Calcification* and *ossification* are also of very frequent occurrence (*osteochondroma*). The cartilage may be wholly replaced by a vascular granulation tissue which becomes bone, so that the chondroma becomes an osteoma. All of these different mixed forms of chondroma such as *fibrochondroma, myxochondroma, lipochondroma, osteochondroma,* etc., in reality represent different stages and differentiations of the same chondroblastic tissue. Subcutaneous chondromas may cause pressure atrophy of the skin and give rise to the so-called *atonic cartilaginous ulcer* which shows little tendency to heal and frequently becomes infected and gangrenous.

The blood-vessels of chondromas are often very numerous and ectatic, giving the tumor a cavernous or angiectatic structure (*chondroangioma*). The cartilage masses may project directly into the vessels or blood spaces, being separated from the blood by an endothelial layer only. Direct extension of the growing cartilage into lymph vessels and veins has been observed, most probably as the result of pressure atrophy of their walls. In many chondromas the blood-vessels are embryonic in type. Nerves and lymphatics are not found in the chondroblastic tissue proper. The development of cartilage in endotheliomas (*chondroendothelioma*) of the salivary and lacrymal glands forms a point still in dispute. By some writers these tumors which are common in the parotid (about ninety per cent. of all parotid tumors), are regarded as mixed *teratoid* growths containing epithelial structures. Certainly in many of them the chief features are proliferation of the blood-vessels with a formation of a hyaline matrix between them. This hyaline matrix compresses the vessels, leaving the endothelial cells in cords and strands, and the growth may assume the appearance of a *cylindroma* or if cartilage develops in the hyaline matrix the neoplasm becomes a *chondroendothelioma*. Cylindromatous areas are almost always found in the latter. Von Dembowski has described a chondroendothelioma of the ear in which the cartilage arose by a similar metaplasia from the hyperplastic endothelium of the ectatic and cavernous blood-vessels of the growth, the endothelial cells becoming separated into groups through the formation of a hyaline intercellular substance, and then becoming changed from a polygonal to a round form with the development of capsules.

In general it may be said that the chondromas attached to the skeleton are more often hyaline with a more or less marked tendency to the formation of bone or osteoid tissue. Those arising in the soft parts are usually composed of fibrous cartilage and show more or less marked mucoid degeneration.

Manner of Growth.—The chondroma usually grows by expansion, but may break through its own capsule and invade veins and lymphatics. In these vessels there may be a growth by continuity; and cases are reported in which disconnected metastases were produced in this way, particularly in the lungs. Weber's and Paget's cases are usually quoted as classical examples. That the primaries in these cases were not chondrosarcomas is open to question. The writer has seen cartilaginous metastases in the spleen and mesenteric lymph nodes from a malignant teratoma of the testis, the chondroblastic tissue alone being found in the metastases. In such a case the transported cells were probably young, undifferentiated forms that later gave rise to cartilage.

The rate of growth is usually slow, but progressive; long periods of rest may alternate with those of more rapid growth. The complex and mixed forms grow more rapidly than the simple forms. Nevertheless a slowly growing osteochondroma of the bones may after twenty-five years of extremely slow growth suddenly become active and increase rapidly in size. In such cases the microscopic examination shows cellular areas of rapid proliferation, giving the picture of a *chondrosarcoma*. These cellular portions may break through the capsule and infiltrate the neighboring tissues and set up metastases. Usually in the slow growth of a chondroma the soft parts are pushed aside or become atrophic through pressure, while firmer structures like nerve-trunks and tendons may cause indentations in the tumor mass or even be surrounded by it, so that they come to lie in canals passing through it.

If all of the chondroma with its capsule and the tissue bordering immediately upon it is removed there is usually no recurrence, except in the case of chondromas of the pelvis and larger bones which have a greater tendency to malignancy. The chondromas of the soft tissues and phalanges, if completely removed, do not usually recur. The prognosis, however, should always be controlled by a microscopic examination.

Etiology.—Chondromas are often *congenital* and *inherited*. This is true particularly of the benign *multiple chondromas* of the bones developing near the epiphyses. The chondromas developing in childhood and at the age of puberty are also probably congenital and due to some disturbance in the development of the bones. Trauma is frequently regarded as the exciting cause; and, as in the case of other forms of neoplasm, this may be the factor responsible for the development of the chondroma on the base of some congenital anomaly. Fracture of a long bone is most frequently regarded as the injury bearing a causal relation to the development of chondroma; in such a case the neoplasm may arise as the result of some disturbance in the process of repair. Some of the traumatic ecchondroses and chondromas of the capsules of the joints are hyperplasias rather than neoplasms. In some cases there appears to be a congenital tendency of the tissues of the capsules of the joints to form cartilage.

For an explanation of the origin of many chon-

dromas the theory of a disturbance of development answers well, since the relation of many of these tumors to irregularities of development is very striking. Aberrant cartilage anlage without the development of a neoplasm are frequently seen in the medullary canals of the bones, in the neck, tonsils, kidneys, etc. The enchondromas of the periosteum or endosteum (phalanges, long bones, clavicle, etc.) may be explained as the result of a defective development of the primary anlage, or of disturbances in the embryonal or postfetal development due to rachitis or trauma. Likewise, the multiple congenital ecchondroses (cartilaginous exostoses) are explained by Albrecht and others as "rudimentary end-bones" resulting from a systemic defective development. Such multiple cartilaginous exostoses are present at birth or develop during the period of growth or at puberty, growing as the skeleton develops. Other malformations and deformities of the skeleton are usually associated with this systemic defect (dwarfism, etc.). The multiple ecchondroses of the respiratory passages (*tracheopathia osteoplastica*) may be in part inflammatory, or in part neoplastic due to a disturbance of development whereby the new formation of cartilage takes place in the mucosa.

The chondromas of the soft parts and internal organs are partly the result of a *metaplasia* of connective tissue, but are chiefly to be ascribed to a *displacement of embryonal anlage.* Thus the chondromas of the neck, thyroid, tonsils, and salivary glands are explained as *branchiogenic chondromas;* the chondromas of the ear are derived from the branchial arches or auricular cartilages; the chondromas of the larynx, trachea, and lung are derived from the cartilaginous anlage of these organs; those of the pleura and mamma from the costal cartilages and clavicle, and the ecchondroses of the clivus from remains of the chorda (see *Chordoma*).

The chondromas of the kidneys, ovaries, and testes are complicated mixed *teratoid* growths in which the chondroblastic tissue has become predominant. These growths are especially likely to take on the character of malignant teratomas, and from these especially may metastases of chondroblastic tissue be expected. Similar teratoid tumors containing cartilage are found in other regions of the body (sacral and coccygeal regions, mediastinum, nasopharynx). In some cases the teratoid formations represent a parasitic twin.

Diagnosis.—A slowly growing, hard, and firm tumor connected with cartilage or bone, or in soft parts where cartilaginous tumors are known to occur should suggest chondroma. The nature of such a tumor should always be confirmed by a microscopic examination. Only through this can a definite prognosis as to the future be given.

Treatment.—This is purely surgical, in the case of single chondromas. The multiple chondromas of the phalanges and joint capsules are hopeless, except perhaps in the earliest stages, when they might be removed in part, at least sufficiently to prevent marked deformities. In the removal of isolated chondromas of bone the fibrous or bony capsule of the growth must be completely removed with a good border of surrounding tissue. This rule applies also to the chondromas of the soft parts and internal organs.

Prognosis.—This varies greatly in the case of different forms of chondromas. The chondroma or osteochondroma of the long and flat bones is always a tumor that should excite suspicion. Particularly on the pelvis, scapula, and bones of the arms and legs do they show a tendency to develop into chondrosarcomas. Even after a slow growth of twenty to thirty years malignancy may suddenly develop in such neoplasms. It is best always to regard all isolated chondromas of the bones as potentially malignant. Between the chondroma and the chondrosarcoma there is no sharp line. The chondromas of the salivary glands become malignant in only a small percentage of cases, but they recur quickly if any portion of the tumor is left behind. The osteochondroma of the mamma is usually an osteochondrosarcoma. The chondromas of the testis are practically always a part of a malignant teratoma, and the prognosis in such cases is grave. The multiple chondromata of the epiphyses are slowly progressive, until the patient becomes practically helpless. In the other internal organs and soft parts the prognosis is dependent upon the size of the growth and the effects of the pressure exerted by it.

Aldred Scott Warthin.

**Chondromucoid** forms one of the nitrogenous constituents of cartilaginous tissue and upon decomposition yield an ethereal sulphate, chondroitin sulphuric acid. The latter upon treatment with acid is broken down into sulphuric acid and a nitrogenous substance, chondroitin, which may be hydrolyzed to acetic acid and chondrosin, a gummy nitrogenous body, soluble in water and having a strong reducing action on metallic oxides. Glycuronic acid and glucosamine may be obtained from chondrosin. Chondromucoid responds to the ordinary protein tests.

Frank P. Underhill.

**Chondrosarcoma.**—See *Sarcoma.*

**Chondrus.**—*Irish moss; Carrageen; Pearl moss; Killeen.* The dried plant of *Chondrus crispus* (L.) Lyngbye (fam. *Gigartinaceæ*) (U. S. P.).

This marine alga, or sea-weed, when growing, is of a purplish or reddish color, but becomes, by being bleached for the market, of a pale yellowish or brownish-white. It possesses a flat, many-times forked or lobed thallus, of very variable appearance, sometimes with broad, flat, wedge-shaped, wavy, and incised, margined lobes, at other times with linear, roundish, blunt, or emarginate ones. It is from five to twenty centimeters high, of a translucent, gelatinous consistence. The fructifications (cystocarps) are embedded in the substance of the thallus, along the smaller branches, where they can be felt as little, wart-like indurations beneath the surface. This alga grows abundantly along the rocky shores of Western Europe and Eastern America, that is, on each side of the North Atlantic. It has for a long time served as an innutritious food, and as the basis of vegetable jellies for the table; it is also, in some localities, fed to cattle, and used as a stuffing for cheap mattresses. For medical or table use it is bleached in the sun, washed, and dried. It is then hard, horny, and brittle, but resumes its original size and consistence after long soaking in water. In boiling water it almost completely dissolves. Taste mawkish, mucilaginous, and more or less saline, according to the thoroughness with which it has been cleansed. It will make a stiff jelly with twenty or thirty times its weight of water.

Composition.—Chondrus consists chiefly of the peculiar mucilage-like body *carragenin,* common also to many other algæ, swelling and nearly dissolving in water, and drying to a hard, transparent substance. It is precipitated by alcohol, and holds tenaciously about one-seventh its weight of mineral matter. It contains, in common with other marine algæ, minute quantities of iodine and bromine compounds.

Medical Employment.—For colds, coughs, and especially acute pharyngitis, a thin mucilage (decoction) made of Irish moss is a popular household remedy, and corresponds exactly with the mucilage of elm and flaxseed, made in the same way. It may be sweetened

and flavored with lemon. Boiled with milk it makes an agreeable jelly ("blanc-mange"), often used as a sick diet, whose value depends on the milk.

H. H. Rusby.

**Chopart, François.**—Born in Paris, France, October 30, 1743. Although his real name was François Turlure, he adopted by preference his mother's maiden name, Chopart, and was known by that name during the remainder of his lifetime. He received a careful general education, and manifested at quite an early date a predilection for surgery. On July 20, 1770, he passed his examinations with great distinction, receiving the title of Master of Surgery. One year later he was made a professor in the *École Pratique*, and still later (1782) he succeeded Bordenave in the chair of physiology. His death occurred in 1795. His chief writings are the following: "Mémoire sur les contrecoups dans les lésions de la tête," in Les Prix de l'Académie de Chirurgie, tome iv.; "Traité des maladies chirurgicales et des opérations qui leur conviennent," Paris, 1780; "Traité des maladies des voies urinaires," Paris, 1791. On page 85 of vol. iv. of "La Médecine éclairée par les sciences physiques," will be found an account of the first partial amputation of the foot performed in accordance with the method universally known as "Chopart's amputation" (disarticulation at the midtarsal joint, leaving only the astragalus and calcaneum, with the soft parts of the sole of the foot to cover the stump). (Dict. Hist. de la Méd.)

A. H. B.

**Chordee.**—This condition, called also *chorda venerea*, manifests itself in more or less persistent erections, during which the penis is curved like a bow or bent at an angle. Near the center of the concave side of the bow and at the interior of the angle, palpation reveals hardening of the tissues. This hardening may be circumscribed or diffuse. The patients compare their sensations during chordee to the feeling of a tense string or a red-hot wire drawn through the penis or urethra.

Chordee is due to cavernitis, either of the penis or of the urethra, or of both, in hyperacute gonorrhea; it may also be produced by the use of excessively strong injections, by an injury to the urethral mucosa, by the use of a sharp-pointed syringe, or by the unskilful introduction of instruments, during the acute stage of urethritis. It may, furthermore, be due to infarction of urethral crypts and glands, with or without consequent periurethral or cavernous abscess. In some cases induration continues without either of these terminations for years, and may then become an impediment to copulation on account of deflection of the penis during erection.

In chordee the penis is bent in the direction of the infiltration that causes it, because the infiltrated part does not take part in the general turgescence of erection. The intense pain produced by such erections may drive the patient to desperate measures, such as placing the organ upon a hard surface and striking it a violent blow "to break the cord." Some patients have sought relief by coitus. The results of such violence may be urethral rupture, fatal hemorrhage, urinary extravasation, and consequent death from urinary infection, laceration of the corpora cavernosa, and gangrene of the penis. Even in those cases in which neither a stricture nor any one of the results just enumerated occurs, the part of the penis in front of the injury may thenceforward be cut off from sufficient blood supply to enable it to participate in erection.

Treatment.—In the acute stage, rest in bed under light covering, a low diet, purgatives, camphor or its monobromate, with or without opium, may be prescribed with advantage; locally, hot sitz-baths, hot or cold compresses—whichever the patient finds most soothing—and leeches to the perineum, are indicated. The far greater majority of patients can be rapidly relieved by the insertion every three hours, until physiological effects are obtained, of a suppository of codeine phosphate (gr. $\frac{1}{4}$–$\frac{1}{2}$), or in combination with iodoform (grains ii.–iv.). In hyperacute cases, the infiltrated tissues may be punctured with fine needles, as a last resort, if the other treatment does not suffice. If an abscess forms, it invariably "points" toward the exterior, hence it must be opened early and thoroughly drained to prevent a urethral fistula. In chronic cases, where the infiltration has become solid and gives but little or no pain during the deflected erection, galvanism may be used to stimulate absorption of the infiltrated material. If it is employed the negative pole should be applied to the infiltrated tissues and the positive to the opposite side of the penis. At first a low amperage should be used for several minutes, but afterward the séances should gradually be lengthened until they reach a term of from twenty to twenty-five minutes each.

Ferd. C. Valentine.
Terry M. Townsend.

**Chordoma.**—The term used by Ribbert to designate a small tumor found occasionally in the median line of the clivus, near the union of the sphenoid and occipital bones; a tumor to which Virchow had previously given the name of *ecchondrosis physalifera sphenooccipitalis*. The growth, to the naked eye, has a colloid or gelatinous appearance, and is usually about the size of a pea or small cherry. It arises out of the sphenooccipital synchondrosis, and either occupies the space between the bone and the dura mater which may not be perceptibly elevated, or it may break through the dura into the arachnoid and pia. It is often closely attached to the basilar artery, so that when the brain is removed the slender pedicle in the dura is torn and the little tumor is found hanging to the artery. In longitudinal sections of the clivus the tumor is found to lie in a small cavity which involves only the superficial portion of the bone or it may extend into the medullary portion. In young individuals whose synchondrosial cartilages are still present earlier stages of the tumor may be found. In these cases there is present beneath the dura, which is usually not elevated, a small round or flattened mass of tumor tissue lying in the cartilage from which it is sharply, though irregularly, outlined. No evidence of transition between the tissue of the new growth and that of the neighboring structures is ever observed.

The tissue of the tumor when examined in the fresh state is found to consist of large bladder-like cells resembling plant cells. These are easily isolated by teasing in normal salt solution. They contain numerous vacuoles of varying size which may so fill up the body of the cell that the protoplasm appears to be pushed in a narrow ring to the cell periphery. Few of the cells are free from vacuoles. The protoplasm is clear and contains fine shining granules. The small round nuclei appear bright and clear. The gelatinous portions of the growth break up in water. In hardened preparations the vacuoles appear still more prominent, but are oval or flattened rather than round. The protoplasm appears in lesser amount, but the small round nuclei are brought out very distinctly. These lie either at the edge of the vacuoles, or when the cells are seen from above they appear to be in the center of the vacuole. While resembling cartilage cells to some extent the cells are distinct and show the characteristics of notochordal tissue. Between the cells lies a homogeneous hyaline intercellular substance varying in amount in

different portions of the growth. No blood-vessels have been found.

Virchow regarded the growth as a chondroma developing from the remains of the sphenooccipital cartilage, the cells of the cartilage having undergone a peculiar bladder-like degeneration. But the character of the tissue as well as the relations of the tumor makes it very probable that it represents remains of the tissue of the notochord, which have taken on proliferative activity; and Ribbert's view as to its notochord origin are now generally accepted. Chordomas have also been reported as occurring on the anterior surface of the cervical vertebræ and on the sacrum. A malignant transformation of a chordoma has also been reported. According to Ribbert a small chordoma about the size of a split pea is found on the clivus in two per cent. of all autopsies. Slight remains of the notochord may be found in the intervertebral disks, but no tumors arising from these have as yet been reported.

ALDRED SCOTT WARTHIN.

**Chorea.**—*Synonyms:* Sydenham's Disease; St. Vitus' Dance; Danse de St. Guy, de St. With; Myotyrbie (Dartigues); periodical jactitation (R. Watt); Chorée, Veitstanz, Veitsdands, Vit-Táncz; Plasawicy scelotirbe; Corea; Folie musculaire (Bouillaud).

The literature of chorea is extremely voluminous, and its history dates back to the middle ages, when it existed chiefly in its epidemic form. Hecker[1] and others detail the incidents of the various religious pilgrimages to the shrines of St. John and of St. Vitus, and the imitative features of the outbreak of psychical excitement with convulsions and jactitations are of the greatest interest. In many respects this form of trouble, apart from its general character, differs but little from that in which attacks of hysterical chorea major are witnessed to-day.[2] Puccinatti and other writers have undertaken to fix the identity of sporadic and endemic chorea, and to some extent they have succeeded; but when we consider the probable pathology of the disease from the standpoint of modern investigation, it must be admitted that the psychical element is by no means an important one. During the last thirty or forty years, thanks to Kirke, Ogle, Dickinson, Dowse, Jackson, Eisenlohr, and Elischer, the relations of the disease to affections of the heart, to embolism, and to rheumatism have been made very clear, and within a comparatively short space of time the organic variety known as post-hemiplegic chorea, or hemichorea, has been fully described by Mitchell, Charcot, Hoffman, Jackson, and others.

Chorea is a disease which manifests itself in an exceedingly irregular manner as to the parts affected, and the degree of violence of expression, and as to its association with or dependence upon other things. The affection is characterized by a peculiar disorderly and nearly constant recurrence of muscular contractions of an involuntary character, which are not (except in hysterical cases) at all rhythmical. It has been divided into *general chorea*, or *chorea magna*, and *partial chorea*, or *chorea minor*, and the manner in which it is associated with other pathological conditions still further demands a series of qualifying terms, such as *hysterical, saturnine, procursive, habit, senile, rheumatismal, dental, enteric, hereditary* or *Huntington's, electric* (of Dubini or Bergeron), the *chorea of insanity*, the *chorea of pregnancy*.

SYMPTOMS.—Chorea may follow some other affection—one of the ordinary diseases of childhood, for instance—or it may be the sequel of an attack of acute rheumatism; or again, it may have no basis except a general reduction of vital power with anemia and its belongings, or be due to fright. In such cases the development of the malady is slow and insidious, and the child for a long time presents simply those evidences of neural malnutrition which are so common. It is peevish and capricious, and restless in the extreme. Its petty exhibitions of temper render it a nuisance, and it receives its full allowance of punishment. The same caprice of disposition is found in eating—it prefers improper food, and at best eats but little. It is listless and dull at school, sleep is disturbed, and frightful dreams produce night terrors and nocturnal incontinence. Its pale face makes more conspicuous the dark spots under the eyes, and its foul breath and dry teeth betoken a derangement of digestion. After a while it begins to shrug one shoulder or the other, and twitches its hands, or fumbles the seam of the trousers, or opens its mouth with a sort of gasping movement, or twitches its lips, or corrugates its brow, or spasmodically closes its eyes; or does something else that may be regarded as a trick or bad habit. Scolding or whipping does not effect a change of behavior—in fact, it rather aggravates the trouble. In a week or two the movements are more pronounced or general, the arm is swayed hither and thither by the action of the pectoral muscles, or the hand is supinated or pronated, the fingers restlessly cramp, the lips are pursed, and any attempt at speech is attended by hesitation and embarrassment, and oftentimes by great indistinctness. The patient breathes in a catchy, quick way, and if the body is stripped it will be found that the action of the intercostals is uneven. There is rotary swaying of the body, constant shrugging of the shoulders. The leg of one side—usually the right—is affected, and after a while there is more or less loss of power, so that there is a well-marked dragging of the limb, which is usually more noticeable toward the latter part of the day. All the voluntary muscles are more or less affected, and as a rule those are most involved which are used to the greatest extent in acts which become automatic. In the form known as laryngeal chorea the thyrohyoid muscles are affected, and phonation becomes seriously embarrassed. The tongue, when protruded, is found to be the seat of jerking spasms, and when the patient talks he makes a peculiar sucking motion of the lips.

Symptoms of spinal sensory irritation mark the prodromal period, and we are furnished with a history of pains and sensitiveness of the vertebral spines.

Pressure on the cervical region sometimes causes great distress, and especially is this the case when even light pressure is made upon the *vertebra prominens*. The patient complains of pains in the wrists and ankles, which suggest rheumatism, and the bellies of the affected muscles are sore.

Spots of cutaneous hyperesthesia or anesthesia are sometimes detected. In hysterical chorea the latter are very often present, and I have repeatedly found hemianesthesia upon the left side.

The vision is affected, and, as a rule, errors in accommodation are found. So common is hypermetropia that it has been advanced as a cause of the disease, and a most absurd therapeutic course, which involves the use of glasses and operations, has been advised by one individual; but Dr. C. S. Bull exploded this theory, showing by statistics the frequency of hypermetropia in non-choreic children and others. In debilitated subjects it is not difficult to get a history of dimness of vision, and sometimes we find pupillary alterations which consist usually in dilatation, and the pupils, as von Ziemssen has observed, are very sluggish.

Electrical response is somewhat altered. Rosenthal[2] found an increase in the electromuscular contractility, with weak currents, in those patients who suffered from unilateral chorea. Galvanic excitability was pronounced, and cathodal opening with weak currents produced contraction. Benedikt obtained the same results, and also found that the electric sensibility is much exaggerated, and, when the electrode is applied to the cervical or dorsal region, eccentric pains in the limbs are complained of.

The presence of cutaneous eruptions is not uncom-

mon. Eczema, as was originally shown by Fraenkel and myself, bears a very close relation to chorea, especially in children.

The movements, as a rule, cease when the patient sleeps, but this is sometimes not the case in pronounced or violent examples. Of one hundred and fifty-eight cases collected by Sée this was the rule, there being but six exceptions.

Dr. Hobart Amory Hare[3] has conducted some investigations which go to show that monochorea is associated with elevation of temperature in the affected limb. Most of the conclusions were arrived at by simply estimating the degree of heat by applying the hand to the part or by the subjective complaints of the patient. When the thermometer was used a difference of four or five degrees was often found to exist between the two sides of the body.

The psychical changes in chorea have impressed such observers as Romberg, Skoda, and Marcé. This latter writer has referred to cases in which hallucinations were present, and feelings of dread were very pronounced: while Rosenthal mentions an old woman who was unusually garrulous and loquacious, and gave "utterance to savage cries." The hallucinations are most often presented in the half-waking state, and are, as a rule, visual. A case in which hallucination of an extremely interesting character was a feature is related by Ritti, the subject being a girl aged nineteen. The hallucination consisted in derangement of all the senses, but principally of sight. She saw cats, bright lights; heard the voices of men close to her; perceived imaginary smells, tasted poisonous substances, etc.

Thore[4] reports a case of melancholia in a chlorotic girl, aged sixteen, who suffered from disturbed menses. Six weeks after the commencement of the melancholia she developed chorea which involved both extremities on the left side. She had auditory hallucinations at night, suicidal tendencies, more aggravated melancholia; and recovered, six weeks afterward, when the menses were reestablished.

I have seen a number of cases in which mental perversion was conspicuous. Two cases in particular now occur to me. One was that of an old woman who had general and very severe chorea, and who for ten or twelve years was a confirmed chronic maniac. The other case was that of a young woman, aged twenty-five, who suffered from hysterical mania. In the first case the autopsy revealed very extensive cortical degeneration. I think, as a rule, that the form of mental trouble presented by choreics is that of excitement, and the psychical derangement is more common among adults than among children.

Some writers speak of a marked loss of memory; this I have never found except when the chorea was associated with dementia.

The urine of the choreic patient is often copious in amount, and, in those cases in which there is a rheumatismal complication, is apt to be loaded with the urates and phosphates. Sugar is occasionally found. Franque reports the case of a boy who suffered with chorea major, and whose urine contained sugar after each violent attack. In the intervals it was normal. This relationship, however, cannot be regarded as a matter of very great importance. Hanfield Jones, who has repeatedly examined the urine of these patients, thus tabulates the result of his urinary examination: "1. In tolerably severe cases, during the full sway of the disorder, the urine may be of high specific gravity, 1.030 to 1.040, contains an excess of urea; after crystallizing copiously with half its volume of nitric acid, deposits sometimes lithates, sometimes phosphates; its color is full, and on boiling with one-fourth its volume of muriatic acid it darkens extremely. 2. The total amount of urea and of phosphoric acid excreted in twenty-four hours may be greatly in excess. 3. In convalescence the specific gravity falls considerably, the color becomes paler, there is less darkening when the urine is boiled with muriatic acid, and the amount of urea and phosphoric acid may diminish to less than one-half. 4. The bodily weight increases during the period of convalescence. 5. It does not appear that the nervomuscular agitation determines the increased excretion of urea, as the latter may be very marked in the paralytic form of the malady."

*The relation of chorea to rheumatism and cardiac disease* is one of the utmost importance. In 1839, Bright first insisted upon the recognition of the association of chorea with affections of the heart and pericardium, and in 1849 and 1850 Roth and Sée systematically described the rheumatismal origin of chorea. They, as well as Roger and Axenfeld, hold the following general views: Chorea may develop in the subject of acute articular rheumatism. The jactitations may appear in the course of an arthritic attack, but rarely when the temperature is high. The chorea may take the place of an attack of inflammatory trouble, and in the same subject the two conditions may alternate. In other cases the two diseases may coexist and be due to the same cause. Axenfeld speaks of the appearance of chorea in connection with the decline of the acute inflammatory symptoms. There is a species of antagonism in the vehemence of the maladies, says he, and the choreic movements, if present at all during the fever, are of the slightest kind, and limited to a few grimaces of the face.

The relation of chorea to heart disease is generally recognized to occur under three conditions, and these are tabulated by Axenfeld as: 1. When the chorea precedes the heart disease, a simple chorea without antecedent rheumatic trouble, the cardiac affection beginning from three weeks to three or four months after the commencement of the chorea. 2. When the cardiac trouble precedes the chorea, *e.g.* when an attack of pericarditis is followed in from ten days to three weeks by well-established chorea. 3. When the chorea and cardiac affection begin simultaneously, or nearly so.

There are a variety of conditions which complicate chorea. Some of these are of an asthenic nature, and others are coincident of infancy. Sometimes these intercurrent affections exercise a most remarkable effect upon the malady—cutting short the choreic attack. There may be, perhaps, a febrile attack of some intensity, during which the movements are increased until the fever attains the maximum intensity, when a diminution takes place. When the reaction ceases, the movements diminish or disappear. Sometimes such eruptive fevers, as variola, when the force of the poison is exerted upon the nerve centers, produce an augumentation in the force and a continuance of the disease; in fact, it is changed perhaps from a simple functional affection to one of a chronic nature.

Chorea very often makes its appearance in *pregnant women*, usually during the early months of utero-gestation, and may last until a few weeks after delivery, or may become a chronic affection. I have seen many cases originating during the latter part of pregnancy, and lasting for many years; and am inclined to regard the affection as a very grave one in many instances. In these cases it would seem as if some grave embolic lesion took place, and that this was a result of the peculiar condition of the blood that exists in certain chlorotic subjects. In fact, I have several times witnessed the most serious accidents—cerebral venous thrombosis, and the like—which were due to some such blood state. The chorea of pregnant women is more apt to be bilateral, and the tongue is involved. This fact was first pointed out by Romberg. It is more common among primiparæ, and, according to Axenfeld, is quite likely to be associated with hysteriform and epileptiform convulsions, which lead to possible

abortions. In one of Linck's cases the movements were worse when the patient was lying down. There is a lighter form than that which has been described, which is quite common and begins during the early months of pregnancy, and the prognosis of which is not especially bad.

*Hysterical chorea* is rare; that is, the form described by Charcot and Bourneville, which is associated with the hysteric access, and is manifested by rhythmical movements. I have not seen more than half a dozen of these cases; but it is by no means uncommon to find chorea developing in hysterical women, the disease, so far as the movements are concerned, differing little, if any, from the familiar disorder of infancy, only being more violent.

The subject of true hysterical rhythmical chorea will for hours repeat, while apparently unconscious, a succession of movements, let us say of flexion and extension; and while sitting in bed she bows low, recovering herself rapidly, and goes through with this for hours at a time.

*Senile Chorea.*—Adult chorea is an affection often associated with mental decay. The variety peculiar to old age (Chorée des Vieillards) is especially so, and it is frequently met with in association with dementia. The writer has known cases in which the disease lasted fifteen or twenty years, and in one instance the patient was upward of seventy years of age. The disorderly movements are quite general, involving not only the extremities and trunk, but the muscles of the face, so that the subject makes the most horrible grimaces. In such patients there is nearly always a history of cardiac trouble and old rheumatism.

Some *idiots* are very apt to present various disorders of motility, among which are automatic movements and chorea; in this instance the chorea probably being associated with cerebral hemiatrophy and difference in development between the two sides of the body. Ireland[5] speaks of the association of insanity in children with a chorea which is curable.

*Electric chorea,* which was originally described by Dubini, is a disease of endemic character, and it is manifested in a variety of ways: by rhythmical movements which last for weeks; by paralysis and atrophy of the muscles involved in the spasms; by local epileptiform convulsions, general at times; by headache and coma, by delirium, and, finally, by death. Its peculiar character gained for it the names myelitis convulsiva (Härtel) and typhus convulsiva cerebralis (Frua). Delirium and head symptoms usually follow the first four weeks of the disease, and precede the coma (Radcliffe). The duration of the affection is about that of ordinary chorea.

Two very unusual forms of the disorder are known as *tarantism* and *tigrétier*. Both are varieties of chorea major, and are undoubtedly hysterical or imitative in character. The first, which is unknown today, was supposed to be due to the bite of the tarantula. The development of the disease was marked by a period of depression and stupidity; and when the sound of musical instruments was heard, the victims leaped into the air and indulged in a wild species of dance, continuing it until powerless from exhaustion. During the epidemic sexual excesses of all kinds were rife. It is questionable whether after all these were not suggested states of motor excitement.

The tigrétier, a disease of modern times, resembles very much the tarantism, and, in fact, both of these are in many respects like those forms of religious excitement which bring with them suspension of inhibitory control and great disorder of muscular movement. We are furnished with examples both in this country and abroad, and the convulsionnaires in France and the jumpers of Maine may be instanced.

Etiology.—Chorea, as a rule, is a disease of early life, and this may be said to be almost absolute in regard to chorea minor. The more severe affections, which include hemichorea, have, as a rule, some basis of cerebral change. The period, then, at which the disease is most common is between the ages of eight and eighteen; from eight to twelve it is very common. Congenital cases have been reported by Richter and Fox,[6] and Simon has met with it in children a few days old. Of 195 cases reported by Haven, 2 were said to be congenital, 11 were less than six years old, 92 between six and eleven, 58 between eleven and fifteen, 22 between fifteen and twenty-one, and 10 between twenty-one and sixty.[7] Heller[8] also presents a case. In adults we find that cases have been reported at all ages, and, as has been said before, even in advanced life. Some cases begin in childhood and continue through life, and others recur every year for several years and then subside. I have found that the disease is most frequent during the spring or fall. I have repeatedly seen cases that commenced in October and continued until April or May, but, as a rule, under proper treatment the disease is not so protracted. In such cases we often find a history of eczema capitis and gastric derangements, with skin disease and the chorea in association. Sometimes the eczema takes the place of the chorea and marks the period of subsidence. So far as local climatic influences are observed, it would seem as if chorea belonged to cold or temperate countries. Axenfeld states, upon the authority of Rufz de Lavison, that it is unknown in Martinique, Guadeloupe, and other hot places; and I find that, while not unknown in our own Southern country, it is of comparatively infrequent appearance there. It is certain that the negro is exempt, as Weir Mitchell has proved from inquiries he has specially made. I have never seen a case in a negro child. It is more common among the German and American children than among the Irish, so far as my statistics go, and the children of the poor are particularly liable.*

Many authors agree as to the influence of heredity in cases which develop in adult life, and instances are on record in which the parents of the patient had been affected. Trousseau and Hanfield Jones[9] trace out the development in phthisical families, and Day calls attention to the fact that, among the Jews, it is very common and is often associated with epilepsy, or appears in the children of epileptic patients. It is by no means difficult in gouty families to learn not only that several children of the same family have been affected with chorea but that also the father or the mother had been a sufferer from the disease.

As to sex, it is commonly a disease of females, and the ratio is as three to one.

This is especially true when the subjects are between the ages of twelve and fifteen, the time of puberty. Of Pye-Smith's 136 cases, 98 were female and 38 males. Of 62 patients affected between the ages of six and ten, 47 were females, and the remainder males, while between the ages of six and fifteen, of the 106 cases 74 were females and the others males. In the cases in which the disease appears later in life there is a much greater preponderance of female patients, and this is true even of the anatomical form of the disease.

It is scarcely proper in this place to consider the variety of chorea known as posthemiplegic, for this, after all, is a distinct affection, and the spasmodic movements are by no means pathognomonic. A degeneration of the pyramidal columns, from whatever cause, will be quite likely to give rise to choreiform movements.

The influence of fevers, especially those of a zymotic nature, in the development of chorea, is important. Scarlet fever, measles, whooping-cough, and diphtheria sometimes leave after them a most intractable chorea, which oftentimes becomes a chronic affection. Barclay, Bernheim, and others speak of typhoid as a cause or complication.

*Since the enormous arrival in the United States of Russian Jews, this statement may be modified.

Onanism is mentioned as a cause, but I do not attach much importance to this statement, although it appears to find favor with the Germans.

Saturnine chorea may manifest itself in suddenly developed convulsive movements of the limbs. Tanquerel[10] speaks of the "first form of the convulsive variety," as follows: "The face, or one side of it only, one or several limbs, are agitated by rapid convulsions analogous to those produced by electric shocks. Instead of this effect all the parts may be struck with permanent contraction, remaining a longer or shorter time without interruption." It is usually a form of trouble connected with cerebral diseases of a grave type, and is the precursor of thrombosis and cerebral hemorrhage.

The association of chorea with epilepsy is occasional, and, when found, is an affection of long standing. I have met with it frequently in children, and almost without exception the attacks of epilepsy involved the limbs of one side of the body; in fact, there were a hemiepilepsy and hemichorea in association. In two cases there were general convulsions, beginning unilaterally in association with hemichorea. Undoubtedly these cases were associated with degeneration of the paracentral region.

Chorea is occasionally of traumatic origin, and is then, as a rule, dependent upon some grave cerebral lesion or meningeal irritation. Chauveau has reported a case that was dependent upon a cicatrix.

Kinnicutt and Heinemann have pointed out the relations of chorea to certain states of malarial poisoning.

A form of toxic chorea that is observed in adults is the direct result of *tobacco*. It is usually general, but may be confined to the muscles of the face.

Intestinal irritation is a most important cause of chorea, whether such irritation be from intestinal worms or from undigested food. Cases in which the expulsion of lumbricoids was followed by cure are numerous. Tardieu reports a case in which a sudden cure followed the expulsion of eight lumbricoids. I have frequently met with examples of the disease in which immediate relief was afforded after the rectum had been freed from a ball of pin-worms by a free injection of quassia or a saline enema. It rarely happens that the source of intestinal irritation is a *Tænia solium*, but, strange to say, children are sometimes the subjects of chorea from such a cause. Hanfield Jones speaks of a boy, nine years old, who was sleepless for four days and nights, who was in a state of constant motion, whose lips and teeth were covered with sordes, and who presented every appearance of collapse. A dose of oil of male fern brought away a tapeworm seven yards long, and in a few days the patient rapidly convalesced. I have reported elsewhere a case of this kind, and in this as well as in some other cases of chorea the distinguishing features are the sudden development and very violent and general character of the disease.

The influence of *imitation* and *fright* as exciting causes undoubtedly plays a very great part in the genesis of the malady.

Strange considers the influence of two forms of fright (*British Med. Journal*, July 16th, 1881, p. 69), and he believes that in two-thirds of the cases it is the exciting cause. "Fright may operate in various ways, some simple, some more continuous and complicated. It need not be sudden, though that is generally the case. There is a kind of fear or fright to which children are exposed for long periods of time. Ill-tempered parents, especially the mother, may keep a child in perpetual trepidation and dread of punishment for unavoidable disasters. Again, the coming home of a drunken father must often be a source of continual terror to a delicate and sensitive girl. Ghost stories and foolish threats of 'Old Bogies,' and the like, so constantly used by ignorant mothers and nurses, need only to be mentioned to be severely reprobated."

The danger of association of healthy with choreic children has been, I am convinced, very much exaggerated. When the disease develops under these circumstances, the victims are usually hysterical subjects.

The appearance of chorea in children who have been improperly fed is not always regarded with the importance it should be. An excessive meat diet is often responsible for this as well as other neuroses, notably epilepsy and hysteria. In these cases there is very often a history of broken sleep, night terrors, incontinence of urine, and not infrequently somnambulism.

Pathology.—This has been considered by a number of English and Continental observers, the former adhering to the theory of a cerebral origin of the affection. Although autopsies are exceedingly rare, Todd, Stenhouse, and Kirkes, Broadbent, Ogle, Tuckwell, Hughlings Jackson, and Bastian all favor the theory that it is an embolic disease, and that the corpus striatum is its seat. Though Todd was the first to point out this probable origin of the disease, starting from the standpoint of the unilateral spasm and hemiparesis, it was not until 1870, or thereabouts, that Kirkes stated that chorea is the result of irritation produced in the nerve centers by fine molecular particles of fibrin which are set free from an inflamed endocardium and washed by the blood into the cavities of these centers. Appreciating the important relationship of the middle cerebral artery to cerebral nutrition, the other investigators named look upon the corpora striata as the region most often affected. Ogle, Tuckwell, and others have found embolic plugging. Aitken believed the optic thalamus to be affected as well, but it would appear that in the cases under consideration there were sensory alterations.

A variety of experiments have been made by Raymond and other French investigators. Raymond experimentally caused chorea in dogs by wounding the internal capsule and optic thalamus, producing chorea of the opposite side. Le Gros and Onimus[11] were of the opinion that chorea was a disease of the cord. Excitation of the posterior column exaggerated the movements, and freezing this part of the cord produced a diminution in their intensity. The movements were not diminished by section of the posterior root zone, but only by the partial section of the posterior columns and horns.

These observers concluded that the seat of the chorea was in the cells of the posterior horns, or in fibers connecting them with the great motor cells.

Numerous postmortem examinations have been reported, the most important of which are those of Meynert and Ellischer,[12] who found changes in the peripheral nerves as well as cerebral lesions. There are, in a number of chronic cases at least, minute lesions of the paracentral region or some meningo-encephalitic disease.

Prognosis.—Here we have to consider the question of duration of the immediate attack, its probable recurrence, and the possibility of a fatal termination. Attention has already been called to the first two, and I shall simply add that chorea minor is usually a simple and curable affection. In adults this is not the case, for when no other cause can be ascertained, it is unhappily true that the affection is too often indicative of some such gross cerebral disease as tumor or sclerosis, or is a sequence of arterial rupture. I have seen many cases of the simple affection in chlorotic young women, in fact in women of thirty to forty, which was readily curable; so even this rule has its exceptions.

The danger in fatal cases arises from exhaustion, from the debility caused by the constant excessive motion, and by attendant insomnia. In febrile cases the prognosis is decidedly bad if anything like a typhoidal state supervenes.

Numerous fatal examples have been reported.

Griswold[13] relates a case which proved fatal in sixteen days, and Ogle[14] brought forward sixteen other cases.

Haven of Boston has made some very interesting investigations, and has analyzed 200 cases of chorea. From his table it would appear that the average duration of the disease, in twenty-five such cases as he could follow up, was 94.5 days. In others it was seventy-seven days, when arsenic was used.

Gray and Tuckwell have also gathered statistics in a number of cases when no treatment was given, and the average duration was from seventy-two to seventy-six days in different sets of cases. It is not uncommon to find cases which recover in six weeks, and sometimes, under the use of ferruginous tonics, the period may be much shorter.

The tendency to relapses is quite common; in fact, Haven found that there was 1 relapse in 22 cases, 2 in 4, 3 in 2, 4 in 1, 5 in 1, and 7 in 1, and 14 of these recurred in the first six months of the year. Von Ziemssen refers to the fact that recurrences are most common at puberty. Of 33 cases of chorea the notes of which I have kept—and the number would have been much larger were it not for the fact that many were observed at dispensaries, where the attendance is so irregular and floating—I found that in 40 per cent. of the cases there were 2 relapses.

The residual paralysis is sometimes, though rarely, quite lasting. If a hemichorea exists for a year, it is quite likely to be associated with some loss of muscular substance. In one of West's cases—a girl—it was found, three months after the movements had ceased, that the left arm was half an inch smaller than the right. In another patient—who had kept her hands clenched for a long time—there was wasting with contraction.

Diagnosis.—This should be simple enough, if we throw out of consideration those cases of organic origin, the so-called "posthemiplegic chorea." The movements themselves can hardly be confounded with any others. They are coarse, jerky, and irregular, and in no sense rhythmical. The same cannot be said of the movements observed in posthemiplegic chorea, in which, besides eccentric jactitations, there is usually more or less tremor. The movements of chorea may in simple cases be controlled, in part or wholly, by the exercise of the will. Embarrassment and suggestion seem to aggravate the intensity.

The age of the subject is also a determining factor. Those forms of degeneration of the brain or spinal cord in which hyperkinesis is a symptom are comparatively rare in children, the exception, perhaps, being cerebral hypertrophy and hemiatrophy; and here we find errors in development and other concomitant symptoms which render diagnosis quite simple. The choreic athetoid form of cerebral infantile paralysis, always accompanied by rigidity of the legs or associated movements, may sometimes be mistaken for ordinary chorea in children.

In paralysis agitans we have an affection which resembles to some extent certain varieties of adult chorea. We find festination, associated movements, no aggravation by attempt at control, and a "fineness" of the spasms which can hardly be called choreic.

In the diagnosis of the particular cases much depends upon our ability to determine the probable nature of the chorea itself; whether it be due to eccentric irritation, to anemia; whether it be a sequence of one of the zymotic diseases; or whether it be a symptomatic affection, the result of some form of tissue change. These things are important when we come to predict the course of the malady. It will readily be seen how much credit may be gained by recognizing the true nature of a chorea dependent upon intestinal worms or other irritative causes, and promptly curing the same by expulsion of the irritating agents. The connection of the disease with some affection of the heart is also most important to recognize.

Treatment.—This has probably received more attention than that of any other nervous disorder, and the list of remedies, good, bad, and indifferent, is very long. As I have said, there is very little difference between the duration of the malady in those patients for whom the expectant treatment is ordered, and the duration in the case of those who are subjected to a rigorous course of medication of the orthodox kind. In the practice of medicine, masterly inactivity is not always the most prudent method of procedure, but in chorea minor I would counsel the simplest treatment possible. Of the vast horde of remedies, I think we can discard all but three or four, and I will name them in their order of usefulness: (1) Arsenic; (2) iron; (3) the fats.

There is a second list of remedies which are employed for the purpose of reaching special conditions, and among these may be mentioned heat and cold, anthelmintics, sedatives, bromides, antipyrine, salol, etc.

If we do use any of the remedies of the first order, it must be freely and with the idea of getting their full physiological effects; especially is this true of arsenic. In children the dose of the former should be rapidly increased until slight edema becomes visible below the eyes. The syrup of the iodide of iron is of especial service in the anemia of chorea and at the same time may be given digitalis, especially in many cases in which cardiac asthenia is a feature. The French writers favor the division of chorea into many forms with relation to the etiological factors. When such forms are clearly made out, of course it becomes our aim to direct special treatment to the individual cases. In those forms with *rheumatismal* history, salicylate of soda, aspirin, tincture of cimicifuga racemosa, vapor baths, and alkalies are of service; hysterical cases are most helped by the valerianate of zinc, or cannabis indica. In many cases the removal of an ulcerated wisdom tooth is sufficient to effect the disappearance of a violent chorea, and when intestinal worms exist, we are to turn to turpentine, kousso, or santonin.

Should the movements be sufficiently violent, as they often are, to necessitate the use of restraint, I know of no better remedies than hyoscyamine or chloral hydrate. Of the benefit of calabar bean in such cases, I have little to say. It has never been of the slightest service in several cases in which I have tried it, and I may say the same thing of belladonna. Axenfeld recommends opium in large doses, but he wisely cautions those who administer it to children. Gery and Fuster suggest the repeated use of chloroform—in inhalation—several times a day, but this is often impractical or dangerous.

In some cases the remedies cited above may be used hypodermically, but, as a rule, this is an unnecessarily painful mode of treatment. Arsenic has been used in this way.

The cacodylate of sodium may be injected hypodermically in increasing doses, especially in the cases where arsenic is not tolerated by the stomach.

The use of cold is occasionally of great benefit to the choreic patient. The application of the ether spray to the entire spine every day, for ten or fifteen minutes, or the application of cold by means of the ice-bag, is excellent, especially in violent cases.

It is of the utmost importance that the patient should be kept quiet, and that muscular exercise be forbidden. A few hours' seclusion daily, in a dark room, works wonders, and at other times he should be made to assume a recumbent position, if possible. Some patients demand complete isolation at home or in a hospital.

There is no other nervous disease which is helped so much by proper diet as this. Fats are essential,

and a liberal administration of milk and cream as well as fresh butter is highly recommended. Good substantial soups, raw meat, and condensed nitrogenous nourishment should be provided to the exclusion of everything else which simply satisfies hunge. or gratifies the capricious appetite of the patientr Sea air is of immense service, and sea baths, if not too wearisome, are to be advised. Still-water bathing, of course, is to be preferred to surf bathing. Special cases demand other attention, especially the chorea of pregnancy, when it may be found necessary to produce an artificial abortion.

Moral treatment is of great value in many cases. West calls attention to the emotional perversion in choreic children, and speaks as well of the hebetude and weariness of mind, which seem to disappear with the movements. He considers moral therapeutics inapplicable to those cases of partial chorea which sometimes, though not often, last through life. This should consist in removing mental strain, abridging study, instituting a regular life and proper habits, and building up the child's will power. The appreciation of his infirmities by the child should be discouraged, except when they are clearly a bad habit and not the result of disease.

Allan McLane Hamilton.

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**Chorea, Huntington's.**—A peculiar malady of the nervous system, named after an American physician, George Huntington (born 1850), who gave the first comprehensive and distinctive description of the disease in its essential phases. Huntington's grandfather and father had both observed the disease in one of its American foci, Easthampton, Long Island, and chiefly through their studies of several generations of afflicted families the essentially hereditary nature of the malady became apparent.

Huntington's chorea has no relationships whatever to chorea minor, or Sydenham's chorea, that essentially infantile disturbance of cerebrocerebellar tract coordinations following so frequently upon infectious disease or exhaustion. Huntington's chorea is essentially hereditary and chronic, occurring as a rule in adults from thirty to fifty years of age.

The condition did not escape earlier observers by any means. Thilenius gave a report of a case apparently as early as 1816, Rufs another in 1834. Waters made his striking comment in 1841, which was printed in Dunglison's "Practice of Medicine," Vol. II., p. 312. Dr. Charles G. Gorman, of Luzerne, Pa., wrote an inaugural thesis, in 1848, on this affection, which has been lost. Dr. Irving W. Lyon, while house physician at Bellevue Hospital, wrote a paper on Chronic Hereditary Chorea, which was published in the *American Medical Times* in 1863. Huntington's paper appeared in the *Medical and Surgical Reporter*, Philadelphia, in 1872. Since this time a rich bibliography has accumulated which in the Huntington number of *Neurographs*, edited by Dr. William Browning in 1908, mounts to 200 titles.

Etiology.—So far as is known the disorder is hereditary. From eugenic studies of Davenport, Muncie, and Jelliffe (American Neurological Association, 1913) the chief factors or determinants behave as Mendelian dominants. In opposition to the statement made by Heilbrunner that the disorder appears at later intervals in succeeding generations, the evidence of extensive eugenic studies just mentioned, and which include the study of 1,000 cases of Huntington's chorea, limited to a few families, shows that it appears at earlier years in succeeding generations. The data here indicated that the disease behaved as a complex in which age, motor disturbances, and mental defect acted more or less independently one of another, and when all three factors combined, the result was Huntington's chorea. No other etiology is known.

Symptomatology.—The studies just referred to point to the need for discussing the separate factors. But as this is not possible in a short résumé, the older lines of description which regard the disorder as a unit will be followed. Thus one speaks of a very insidious onset, usually coming between the years of thirty and forty. The earlier signs are either slight changes in character, irritability, moroseness, eccentricities, or the choreatic movements become prominent in the picture. The facial, cervical, and upper extremity muscles are usually involved first. There are involuntary jerky movements, usually of muscle groups, not of muscle fibers. The excursions brought about are massive, *i.e.* excessive, loose, and hypotonic. The hand is thrown to one side, the whole arm sweeping outward; the neck is jerked backward, the head bowed forward in a quick, loose-jointed, jerky sort of way. The motor unrest spreads over the entire body. The patient, after several years—for the motor disturbance advances very slowly—becomes very jerky, and although for a long time voluntary movement is able to check the excessive motion, finally control is lost and the patient is confined to a chair or his bed, making his peculiar broad, jerky movements. During sleep the motions cease.

Nearly all of the voluntary muscles may be involved. The eye movements seem to resist to the last. The speech becomes explosive, or grunt like, very incoherent at times by reason of the involuntary movements of tongue, lips, diaphragm and chest. Even swallowing is involved in the later stages. Writing soon becomes impossible by reason of the jerkiness of the hands and arms. Walking grows successively more and more unsteady until the patient becomes bedridden.

There are no disturbances of sensibility. The knee-jerks are active or uninvolved; there are no atrophies, nor paralyses, nor hypertrophies.

The mental changes may develop apart from the motor ones, and in choreic families mental choreics are to be recognized who perhaps may never show motor signs or those who show choreic movements very late. This is the basis of Diefendorf's Constitutionally Defective group. These patients even in childhood may be excessively nervous, irritable, and excitable. They are often difficult children to manage. Their eccentricities become more and more marked with advancing years. Some show marked grades of feeble-mindedness and occasionally are born choreic and defective.

In the greater majority of the cases the insidious and slow development of great instability and irascibility shows itself coincident with or following the choreiform movements. Angry outbursts and destructive impulses occur, often followed or preceded by periods of marked moroseness and despondency. This depression or gloom may be a forerunner of suicide. Diefendorf remarks that this despondency is not due to the realization of having the disease.

In some cases, however, the suicide is to be traced to the knowledge of the taint. Suspiciousness, paranoid ideas, and jealousies are not infrequent mental developments. Emotional deterioration follows. The patient loses all interest in his work, his appearance, his home, etc. Some become tramps. Intemperance and free sexual activities may show

Fig. 1366.

themselves with this gradual deterioration. Indifference shades off into absolute incapacity and deterioration becomes profound, always however showing itself in the affective sphere more prominently than in the intellectual capacities, although these latter are not free from gross defect, the patients being

Fig. 1367.

forgetful, poor in ideas, disorderly in thought, and weak in judgment.

Diefendorf speaks of a group in which the mental symptoms develop somewhat similarly to those seen in the hebephrenic types of dementia præcox. These patients complain of insomnia and general malaise. They often then develop ideas of reference, anxiety, suspiciousness and ideas of infidelity. In some of these impulsive activities show themselves. Homicide has taken place. Kraepelin cites an illustration of a choreic father who killed his three small children by hanging, as he feared he could not support them, then quietly took a walk and was quite unconcerned about the affair at a judicial hearing. The eating is often impulsive and ravenous. In some of these

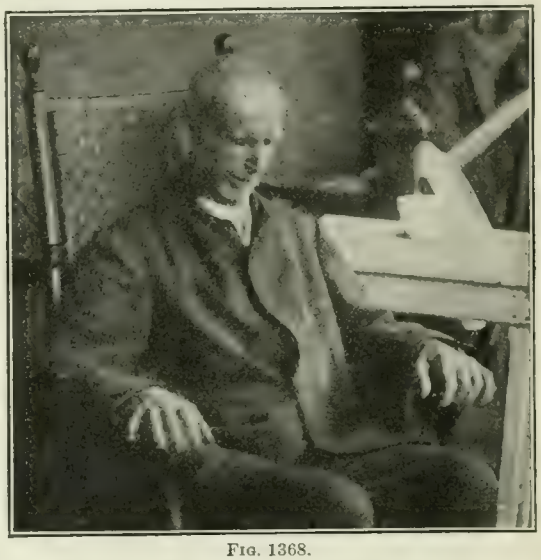

Fig. 1368.

Figs. 1366, 1367 and 1368.—Huntington's Chorea. Movements of the head. (Original.)

cases, as with the inferior group, the mental symptoms may develop long before the choreic symptoms, and the diagnosis of a katatonic schizophrenic may be made as the motor symptoms become manifest. Here the diagnostic difficulties are very definite. It would appear from Diefendorf's and our own studies that the mental and motor traits are more or less independent one of the other. In inheritance they seem to show as such. Some patients have shown choreic movements for twenty to thirty years without mental signs.

Course.—This is subject to great variation. Often the patients suddenly develop great motor unrest; the mental signs augment rapidly, and the patient dies in exhaustion five, ten, or fifteen years after the onset of the symptoms. Usually the disorders, *i.e.* motor and mental, are progressive; rarely they may diminish after reaching a severe grade. Many die of intercurrent disease.

Pathology.—No unitary interpretation seems yet possible. The motor and the mental symptoms are best considered separately.

A number of autopsies have shown a variety of findings. At times there are chronic meningeal thickenings, again generalized brain atrophy. This reduction of the cortex may show to a marked degree in the loss of cells, particularly of the third layer. There is a compensatory increase in neuroglia. In some patients arteriosclerosis has been present, in others none. The older patients showed the arteriosclerotic changes. These cortical cellular changes are apparently more frequent in the motor areas. The cortical degenerative changes are associated with the mental defects.

The pathology behind the motor manifestations is more obscure. Theoretical considerations as well as pathological findings point to an implication of the rubrothalamocortical extensions of the cerebellar pathways as chiefly responsible for the perverted movements. Kleist, Zingerle, Jelgersma, and Winkler

adduce observations from various sides which tend to show that these mechanisms involved ally the motor anomalies to those seen in the paralysis agitans, athetoid, and katatonic types of motor expression. Alzheimer's observations of widespread disorder in the corpora striata are suggestive, but as they are cytological solely the fiber pathology connected with the diseased cells is still uncorrelated. The analysis of the cerebral extensions of the chief cerebellar pathways is still imperfect. It is probable that in them the pathology of the perverted movements is to be sought.

Therapy.—There is no efficient therapy. Many patients need hospital care. Prophylaxis is important, Mendelian dominance showing, for certain factors at least, that these patients should not procreate. The percentage of chance of escape for the choreic's offspring is about one in four at the best. Some branches escape, and a branch once free is practically always free. Only a few exceptions to this are found in the Davenport, Muncie, and Jelliffe extensive series.

Smith Ely Jelliffe.

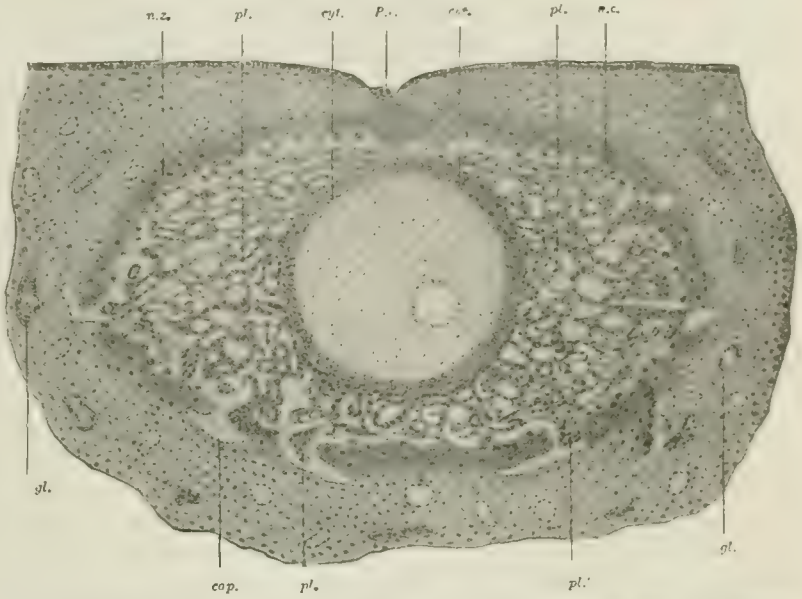


Fig. 1370.—Diagram of the Teacher-Bryce Ovum. *P e*, Point of entrance; *pl*, plasmodi-trophoblast; *n z*, necrotic zone of decidua; *gl*, gland; *cap*, capillary; *cyt*, cytotrophoblast.

**Chorion.**—During intrauterine development the mammalian embryo is surrounded by the amniotic fluid which is confined within a membranous sac composed of two layers. The inner layer, called the amnion, probably secretes the fluid in which the embryo lies; the outer layer, called the chorion, is attached on one side to the amnion, and on the other comes in direct contact with the uterine mucous membrane. (See article on *Decidua*.) The functions of the chorion are to anchor the product of conception at a place where development may progress and to establish a connection with the mother through which nourishment may pass to the embryo and its waste products may be carried off. The highly developed portion of the chorion which thus arranges for the interchange of material between mother and offspring forms the bulk of the placenta.

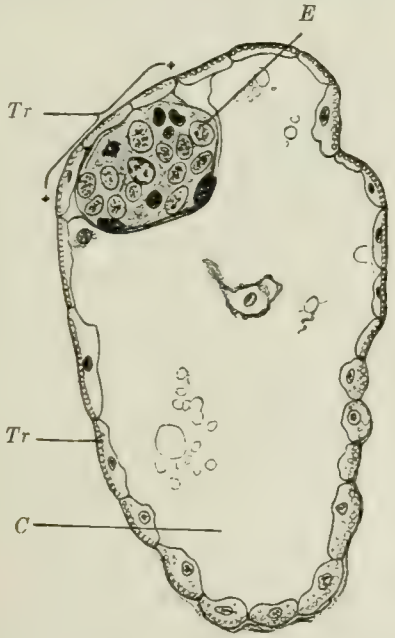


Fig. 1369.—Blastodermic Vesicle of the Deer. (After Keibel.) *E*, Embryonic area; *Tr*, trophoblast forming the primitive chorion; *C*, cœlomic cavity.

In the early human ova thus far described the chorion is not only present but has attained a high degree of development. Its mode of formation in Man, therefore, remains a matter of conjecture; our ideas regarding this problem are based on what is known to occur in the lower animals. It is generally admitted, however, that the chorion has been formed by the time when the fertilized human ovum has reached the uterine cavity, though the embryo continues in a rudimentary stage of development for some days after implantation has taken place. The weight of authority at present does not favor the view, so long accepted, that the human chorion develops like that in the chick. On the contrary it seems probable that the early stages of development in Man are similar to those in Rodents which have been carefully studied by many embryologists, notably by Sobotta in the mouse and by Graf Spee in the guinea-pig. From their observations we may assume that fertilization of the human ovum occurs in the abdominal end of the tube, and that from seven to ten days are required for the journey to the uterus.

While the fertilized ovum is travelling through the tube segmentation takes place, giving rise at first to the morula which soon becomes transformed into the blastodermic vesicle (Fig. 1369). The latter structure may be described as a very minute sac enclosing a cavity into which hangs a group of cells—the embryonic area. At this stage of development the chorion is represented by a single layer of ectodermal cells, the covering of the blastodermic vesicle.

The earliest human ovum with which we are acquainted was described by Bryce and Teacher (Fig. 1370). It was aborted sixteen days after the fertilizing coitus—eleven days after the menstrual period should have begun—and its development is estimated to correspond to the thirteenth or fourteenth day of

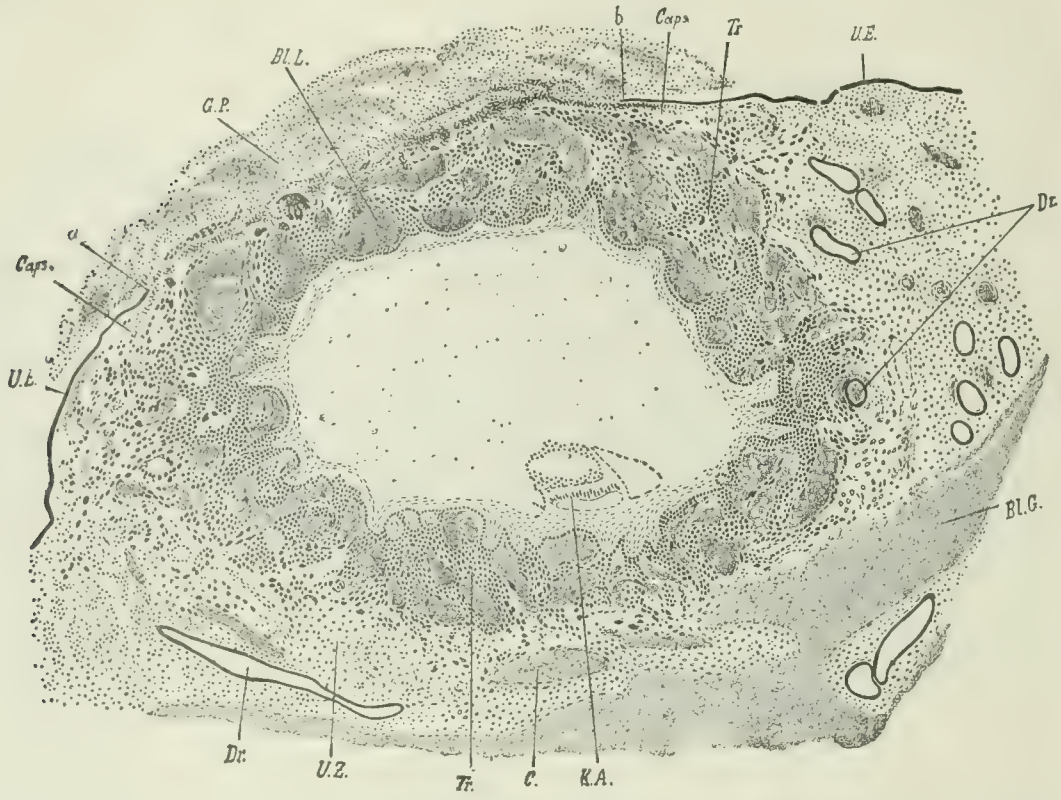


Fig. 1371.—Peters' Early Ovum. *UE*, Uterine epithelium; *BlL*, lakes of blood; *Caps*, decidua capsularis; *GP*, "Gewebspilz"; *Dr*, uterine glands; *UZ*, decidua basalis; *Tr*, trophoblast; *C*, capillaries; *KA*, beginning embryo; *BlG*, large blood-vessels; *a–b*, point of entrance of ovum.

development. The blastodermic vesicle is still spherical in outline but the primitive chorion, originally a single layer of cells, has become converted into a capsule of several layers of ectoderm. The cavity of the ovum is occupied by a delicate tissue of mesoblastic character.

Thus far there have been described twelve human ova the age of which is estimated to be between the fourteenth and twenty-first days. The youngest among them, next to the specimen of Bryce and Teacher, was obtained by Peters at autopsy upon a woman who had committed suicide three days after missing a menstrual period. Basing his opinion upon the clinical history Peters originally thought his specimen not more than three to four days old, but subsequently admitted that the ovum had undergone at least two weeks development.

The ovum (Fig. 1371) measured 1.6×0.80×6. millimeters in its various diameters. It was embedded in the decidua and lay beneath its surface, having apparently burrowed its way through the epithelium. It gives most important information concerning the mode of implantation of the ovum and the development of the decidua. The ovum presented a well-developed chorion which consisted of two layers: an inner layer of mesoderm and an outer layer composed of many layers of epithelial cells, which Peters, following Hubrecht's suggestion, designated as trophoblast.

Protruding from the surface of the chorion were a few elevations, whose interior was filled with connective tissue, representing the earliest stage of the formation of villi. The trophoblast was arranged in many layers and surrounded the connective tissue of the chorion as a distinct capsule. It was made up in great part of round or polyhedral cells, which stained deeply and presented distinct vesicular

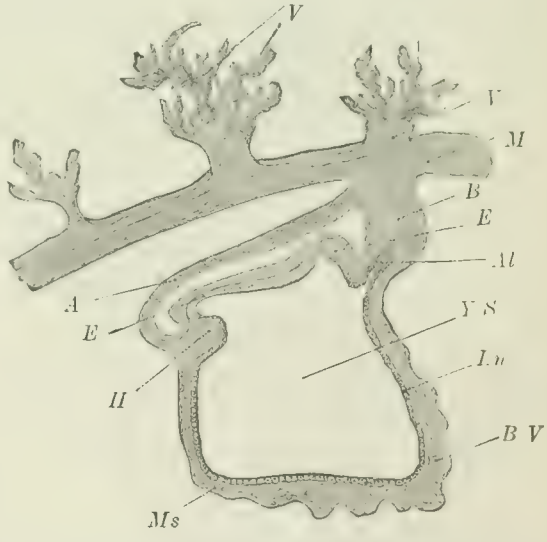


Fig. 1372.—Median Sagittal Section of Spee's "Glaevecke" Ovum. (After Kollmann's Atlas.) *V*, Chorionic villi; *M*, chorionic membrane; *B*, bauchstiel; *A*, amnion; *E*, embryo; *Al*, allantois; *H*, heart anlage; *YS*, yolk sac; *En*, entoderm; *Ms*, mesoderm; *BV*, blood-vessels.

nuclei, between which were a few masses of protoplasm which showed no tendency to divide into individual

cells, through which were scattered irregularly shaped, darkly staining nuclei. The trophoblastic cells were apparently growing very rapidly, and had opened up dilated capillaries in the surrounding decidua, so that numerous small cavities were formed, which were lined by trophoblastic cells and filled with blood, and which probably represent the earliest stages in the formation of the intervillous circulation.

Spee's ovum, cast off from the uterus at about the third week of development, was as an oval body, 9×6.5 millimeters, and consisted of a vesicle which enclosed the beginning embryo. In this specimen the chorion was definitely formed, and consisted of an epithelial and a connective-tissue layer, and distinct villi arose from one portion of its exterior (Fig. 1372).

Very early ova have likewise been described by Jung, Merttens, Beneke, Leopold, Reichert, Rossia Doria, Eternod, and Frassi. In all of these specimens the chorion consists of two layers; an outer epithelial and an inner connective-tissue layer. We have already indicated that the epithelial layer is derived from the ectoderm of the blastodermic vesicle, but it is not so easy to explain the origin of the connective-tissue layer. In all the early ova, the amnion presents a very rudimentary appearance; and it is therefore improbable that the connective issue of the chorion is derived from the somatopleure, in the same way as in the chick.

In its earliest stages the chorion consists of a smooth membranous sac composed of two layers, ectoderm and mesoderm, but it is not long until projections, called villi, begin to appear upon its external surface. At first they are purely epithelial in character, and in Peters' ovum are represented by mere projections of troploblastic cells. At a little later period, however, the center of the villus becomes filled with connective tissue, which is continuous with the inner layer of the chorionic membrane. This is illustrated in Fig. 1373 where it will be seen that the chorion is made up of two parts: (1) a chorionic membrane, and (2) the villi which spring from it.

The chorionic membrane is composed of an inner layer (toward the embryo) of connective tissue, which is made up of branching and star-shaped cells, which are separated from one another by a large amount of mucoid intercellular substance, in which no trace of vessels can be observed. Its exterior is composed of epithelial cells, which are arranged in two layers: an inner layer consisting of distinct cuboidal cells with round vesicular nuclei, and an outer layer made up of a band of protoplasm which is not divided into individual cells, and scattered through which are numbers of irregular-shaped, darkly staining nuclei.

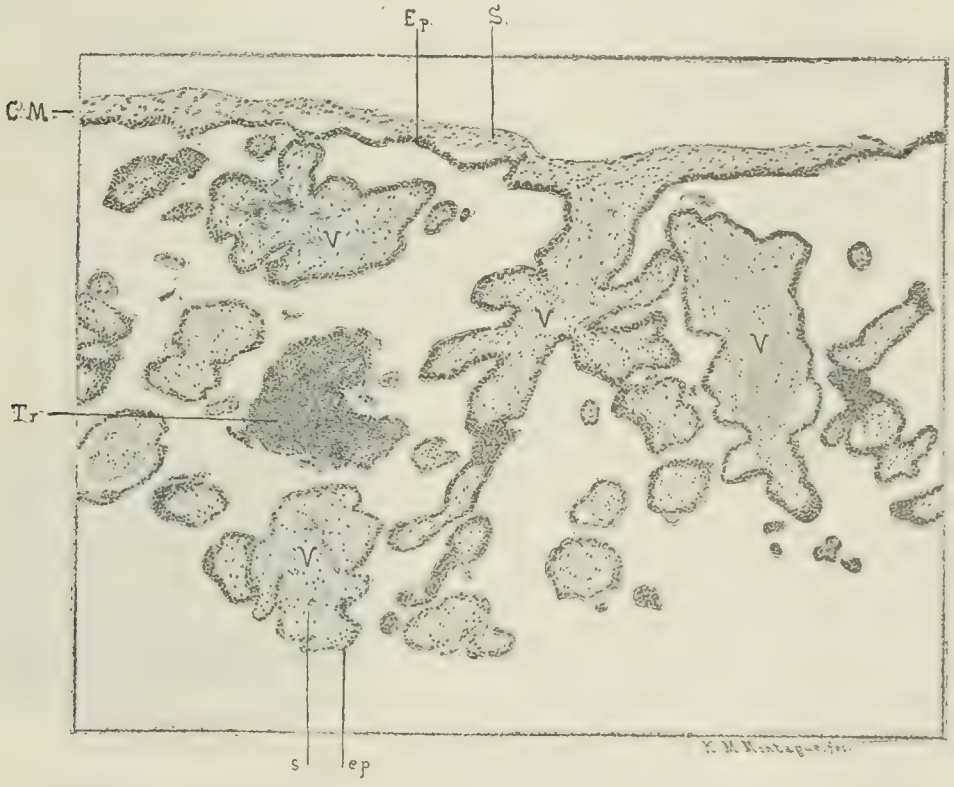


Fig. 1373.—Section through Chorionic Membrane and Villi of a Two-weeks' Ovum. (After Williams' Obstetrics.) Magnified 33 times. *CM*, Chorionic membrane; *Ep*, epithelium of chorionic membrane; *S*, connective-tissue layer of chorionic membrane; *V*, villi; *s*, stroma of villus; *ep*, epithelium of villus; *Tr*, decidual island (remnant of trophoblast).

The villi are arborescent structures which project from the outer surface of the chorionic membrane, and consist of a single trunk or stem, from which numerous branches are given off at something less than right angles. The tips of some of the larger branches extend down to the decidua, and serve to fasten the chorion to it; but the great majority of the smaller branches, after branching repeatedly, end freely and project into cavities which are filled with blood, and which constitute the intervillous spaces of the placenta.

The villi consist of a connective-tissue core which is continuous with the connective tissue of the chorionic membrane, and is covered by two layers of epithelium, just as is the chorionic membrane. None of the villi contain blood-vessels at this period. In several places the epithelium covering them appears to be arranged in many layers, and this is due either

to tangential sections through the periphery of a villus or to the formation of epithelial buds, which represent the earliest stage in the formation of new branches. At one point in the section (Fig. 1373, *Tr.*) there is a mass of cells which present a distinctly epithelial appearance. Such structures are usually designated as decidual islands, and are supposed to be due to sections through decidual septa, which extend from the decidua toward the chorionic membrane. But in view of the marked similarity of the cells composing the mass to those which cover the villi, it seems possible that they represent a remnant of trophoblast rather than a section through a decidual septum.

At a little later period the chorionic membrane becomes vascularized, and large numbers of vessels,

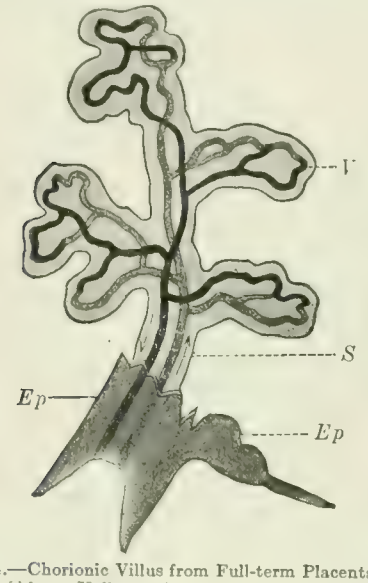


Fig. 1374.—Chorionic Villus from Full-term Placenta. Highly magnified. (After Kollmann.) *Ep*, Epithelial covering; *S*, stroma of villus; *V*, vascular loop.

both arterial and venous, are found just beneath its epithelial covering, branches from which extend into the villi. These vessels are derived from the umbilical arteries and veins of the fetus, and do not communicate with maternal vessels. Their arrangement is clearly shown in Fig. 1374.

It is not definitely known how the vessels first make their way to the inner surface of the human chorion. In many of the lower animals it has been definitely demonstrated that they are derived from a vesicular allantois, which grows out from the embryo between the amnion and chorion, and eventually applies itself to the inner surface of the latter. In man, however, this does not occur, as the extra-embryonic portion of the allantois is very rudimentary and does not assume a vesicular form, being merely a small epithelial duct which extends from the intestinal tract for a short distance into the umbilical stalk (Bauchstiel) (Fig. 1372).

The Bauchstiel is a prolongation of the caudal end of the embryo, and serves to connect it with the inner surface of the chorionic membrane. It contains the umbilical arteries and veins, and at a later period becomes converted into the umbilical cord.

At a still later period of development the chorionic membrane takes on a more complicated structure, and we are indebted to the classical article of Langhans for our first definite information concerning it. He stated that it was made up of four layers: gelatinous (Gallertschicht), fibrillar, vascular, and epithelial. The gelatinous is the innermost layer and lies in apposition with the connective tissue of the amnion. It is composed of mucoid connective tissue, analogous to the Whartonian jelly of the umbilical cord. External to this is the fibrillar layer, in which the connective-tissue cells are more abundant and have become more fusiform in shape, and are arranged in such a way as to give the tissue a distinct fibrillar appearance. External to this is the vascular layer which is composed of loose connective tissue, which surrounds large numbers of blood-vessels, both arteries and veins; while the outermost layer is composed of epithelial cells. The epithelium outside of the placental site consists of several layers of round or cuboidal cells, which stain palely with the ordinary reagents, and present distinct vesicular nuclei with a faint chromatin network, which readily stains with the ordinary dyes. At the placental site these cells are covered by a layer of syncytium, which is lacking in other parts of the chorionic membrane.

The above-mentioned cells were designated as the "Zellschicht" by Langhans, who considered that they were of connective-tissue origin. Further study, however, convinced him that they were epithelial cells derived from the ectoderm of the ovum, and this view is now universally accepted.

For the first few weeks after implantation the entire surface of the chorion is covered to a greater or lesser extent by arborescent villi. But this condition does not persist, and the reason for the change can be understood only by keeping in mind the alterations wrought in the uterine mucous membrane by the imbedding of the ovum. In consequence of the reception of a fertilized ovum the uterine mucosa, now called the decidua, is divided into three parts, namely, (1) that lying beneath the ovum, the decidua

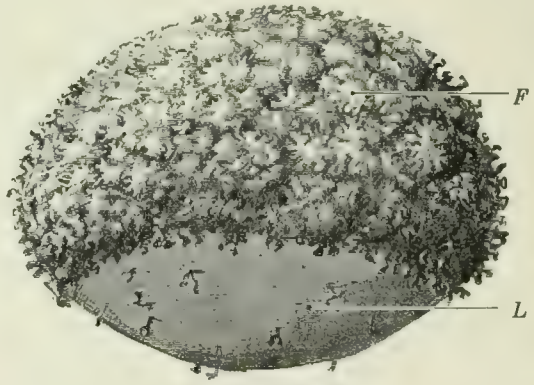


Fig. 1375.—View of Exterior of Human Ovum at the Seventh Week. (After Kollmann's Atlas.) *F*, Chorion frondosum; *L*, chorion læve.

basalis, (2) that which covers the ovum, the decidua capsularis, and (3) the remainder which lies to either side of the ovum, the decidua vera.

From the decidua basalis and the decidua capsularis the chorion is separated by the growing villi, and the spaces thus formed become filled with maternal blood. They are called the intervillous spaces. During the first few months of pregnancy, however, the villi which are adjacent to the decidua capsularis begin to atrophy, so that within a short time the chorionic membrane and the decidua capsularis come to lie in intimate contact, with only the degenerated remains of the villi separating them; while the villi which are in contact with the decidua basalis continue to grow and become larger and larger and give rise to the fetal portion of the placenta. At this period we distinguish between the chorion læve and the chorion frondosum, the latter being the portion which takes part in the formation of the placenta.

(Figs. 1375 and 1376.) For further particulars concerning the structure of the placenta, the reader is referred to the article upon that subject.

The villi of the chorion frondosum (Fig. 1374), as we have just indicated, increase rapidly in size and complexity, and give off numerous branches which form the bulk of the placenta. But it is not probable that the primary villi increase in number after the first few months, the increased thickness of the placenta being due to the branching of the preexisting villi; just as a row of trees, when first planted, is represented by a number of isolated stems, which at a later period are converted into large trees with myriads of branches and twigs. This fact has been strikingly demonstrated by de Loos, who has shown that one can roughly estimate the age of a placenta by the shape and size of its villi. Sections through a young

Fig. 1376.—View of Exterior of Human Ovum at the End of the Fourth Month. (After Kollmann's Atlas.) *F*, Chorion frondosum; *L*, chorion lævе; *A*, amnion; *C*, umbilical cord; *YS*, yolk sac.

placenta show a few large villi with comparatively few branches; while in a more mature placenta one sees large numbers of small branches, which become smaller and smaller as the placenta becomes older.

The stroma of the villi likewise undergoes marked changes as the placenta becomes older. In its early stages it is distinctly mucoid in appearance, and is made up of a small number of stellate cells which are separated by a large amount of mucoid intercellular substance. As the villi become older their stroma becomes denser, and the cells are more abundant and more fusiform in shape, so that toward the latter part of pregnancy it presents a distinctly fibrous appearance.

Coincident with the changes in the stroma the villi become more vascular, and in the second half of pregnancy contain distinct vessels, many of which attain considerable size, the large arteries being surrounded by thick walls.

The epithelium covering the chorionic villi was first described by Dalrymple in 1842, and we now know that it is arranged in two layers: an outer, which consists of a band of protoplasm, which is not divided into individual cells, and to which the term "syncytium" has been applied; and an inner layer of definite cuboidal cells, which was designated by Langhans as the "Zellschicht." The protoplasm of the syncytium presents a coarsely granular appearance; this on careful examination is seen to be due to the presence of vacuoles of varying size. The nuclei which are scattered through it are irregular in shape and contain a thick chromatin network which stains deeply with the ordinary dyes. The Zellschicht is composed of a single layer of distinctly cuboidal cells with vesicular nuclei. Their protoplasm stains very lightly and thus contrasts markedly with that of the syncytium; the nuclei have a very delicate chromatin network, and therefore stain far less darkly than those of the syncytium.

These two layers are readily recognized during the first half of pregnancy, and are clearly shown in Fig. 1377, which represents a section from a three-months placenta. As the placenta grows older, however, the inner layer gradually disappears, so that in the last months almost all trace of it is lost; the villi are then covered only by syncytium. The failure to recognize this fact was the cause of a great part of the discussion concerning the arrangement of the chorionic epithelium; but it is now universally admitted that two layers of epithelium can always be distinguished in the earlier months, and only one in the latter months of pregnancy.

The syncytium is not always arranged in a single layer, but several layers of nuclei may be observed in many places, while distinct buds of syncytial tissue frequently project from the surface of the villi and represent an attempt at branching. In microscopic sections, variously shaped masses of syncytium, containing many nuclei, are found lying free in the intervillous spaces, and are described as placental giant cells. The examination of serial sections will, however, always show that they are cross-sections through such buds, or are due to tangential sections through the tips of the villi.

For a long time the origin of the chorionic epithelium was the subject of bitter controversy, but all recent writers agree that both layers are composed of fetal ectoderm. This view received notable confirmation from the work of Peters, who showed that the chorionic epithelium in the first week formed a distinct, many-layered capsule which he designated as trophoblast, the greater part of which consisted of distinct cells, though here and there small areas of syncytium could be observed. He concluded, therefore, that the fetal ectoderm originally consisted of distinct cells, which assumed a distinctly syncytial appearance where they came in contact with the maternal blood. Peters' conclusions have been confirmed by Bryce and Teacher as well as by all other investigators who have had the opportunity to observe very young human ova.

In 1890 Waldeyer carefully analyzed the literature, and was able to classify the theories concerning the origin of the chorionic epithelium into ten groups, to which several others have been added; all of them are carefully considered in Peters' monograph.

When the tips of the villi come in contact with the decidua basalis, the chorionic epithelium proliferates and invades the decidua to a greater or less extent. This was first recognized by Nitabuch, who pointed out that one could distinguish three layers in the decidua: a deep layer composed exclusively of decidual tissue, above which was a layer of fibrin, and above this another layer of cells which resembled the decidual cells very closely, but which were really fetal in origin. She pointed out that the fibrinous line, which separated these two varieties of cells, was probably the result of degenerative changes in the chorionic epithelium, and accordingly represented the boundary line between the two tissues. Her views have been indorsed by most investigators, and at present it is generally believed that the decidua basalis is not

made up entirely of maternal (decidual) tissue, but that its upper portion contains large numbers of fetal cells.

Not only do masses of chorionic epithelium penetrate the decidua, they also gain access to the maternal circulation and to a greater or lesser extent are transported to the various maternal organs. Emboli of chorionic ectoderm were first noted by Schmorl in the lungs of women who had died of eclampsia. While such emboli, on account of the convulsions, are perhaps more numerous in eclamptics, it is generally recognized that in normal pregnancy varying amounts of trophoblast and even villi are constantly becoming separated from the placenta and carried to various parts of the mother's body. "Deportation" as the process is called has been made the basis for several theories of eclampsia. Veit holds that a hypothetical substance—syncytiotoxin—is contained in the trophoblast, and that this is responsible for the autointoxication. Such a poison, however, has never been isolated; nor does the weight of evidence from animal experimentation favor the conclusions of Veit. Similarly there has been no confirmation of the supposition that eclampsia is of the nature of an anaphylactic reaction attributable to the sensitivization of the mother to a foreign protein contained in the trophoblast. On the contrary it seems probable that the maternal organism develops the means of protection against such harmful consequences as may arise through the deportation of minute masses of trophoblast swept by the maternal circulation from the surface of the placenta.

According to Abderhalden there is in the blood during pregnancy a proteolytic ferment capable of digesting placental protein and of destroying the deported chorionic ectoderm. On these grounds he has devised a blood-test to determine the existence of pregnancy. The serum of the patient to be examined is mixed with a suitable quantity of dried placenta,

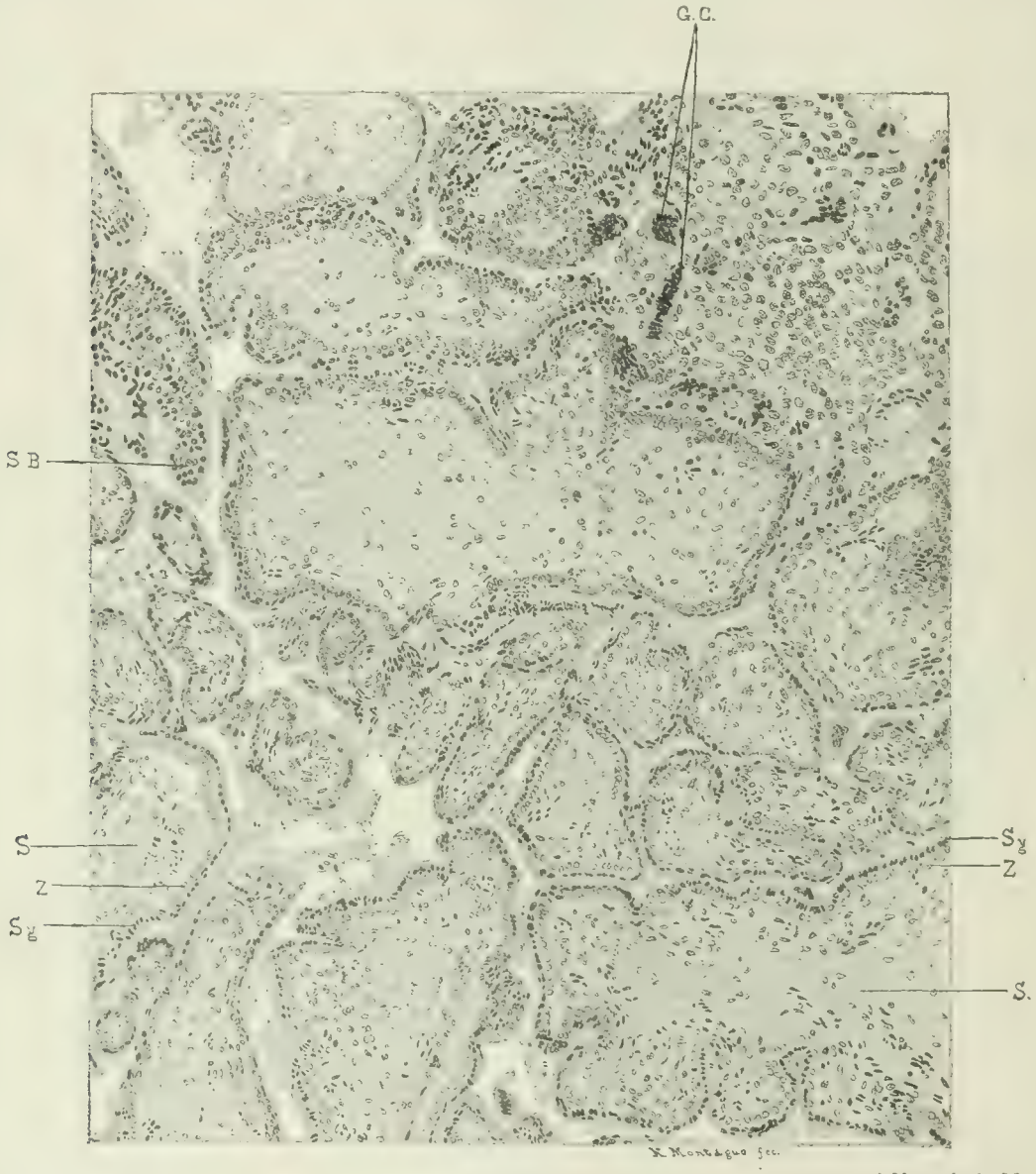


Fig. 1377.—Section through a Three-months' Placenta, Showing Structure of Chorionic Villi. (After Williams' Obstetrics.) Magnified 110 times. *S*, Stroma of villus; *Sy*, syncytium; *Z*, Zellschicht; *SB*, syncytial bud; *GC*, so-called placental giant cells.

placed in a dialyzing apparatus, and allowed to stand in a thermostat sixteen hours. If the woman is pregnant the placental material is digested and the resulting products pass through the dialyzing membrane. They may be recognized most simply by a color reaction (the biuret). Should this method prove trustworthy, it will be the means of making a very early diagnosis of pregnancy and will serve to differentiate between tubal pregnancy and pelvic inflammatory disease.

On examining sections through the chorion outside the placental site, one finds at the end of pregnancy that it differs markedly from the chorion frondosum. Fig. 1378 shows a section through the fetal membranes and the underlying decidua, and in it one can clearly distinguish the following layers: 1. The cuboidal epithelium of the amnion. 2. The amniotic connective tissue. 3. The chorionic connective tissue. 4. The chorionic epithelium. 5. Degenerated villi. 6. More or less canalized fibrin. 7. Typical decidua.

The chorionic epithelium is arranged in a number of layers, and consists of definite cells whose protoplasm stains lightly; the nuclei are vesicular in shape and stain quite darkly. Here and there in the chorionic epithelium one sees numerous large, pale, oval, or round, more or less structureless areas, which represent all that is left of the villi of the chorion leve. Occasionally they contain a few connective-tissue cells, but usually consist of a mass of transparent hyaline material. Beneath the epithelium and degenerated villi one finds a thicker or thinner layer of fibrinous material, which is evidently the result of the degeneration of chorionic epithelium. This tissue was first described by Langhans as canalized fibrin, and is characterized by the presence of numerous slits or canals of varying size. External to the canalized fibrin and chorionic epithelium one sees typical decidual tissue with its characteristic large, pale epithelioid cells.

Where the canalized fibrin is absent, the chorionic epithelium and the decidual cells come in intimate contact, the former extending down a slight distance into the latter. Where the two varieties of cells are commingled, it is almost impossible to differentiate between them; but when one compares distinct masses of chorionic epithelium with typical decidual tissue, it is readily seen that the former is composed of somewhat smaller cells with fairly darkly staining nuclei, while the latter is made up of larger, more irregularly shaped, paler cells, whose nuclei stain less intensely.

After the first few months degenerative changes are almost universally observed throughout the chorion, and usually appear as canalized fibrin. This tissue stains deeply with eosin, and on close examination is seen to contain large numbers of spaces of varying shape, whence its name. It apparently results from coagulation necrosis of the chorionic epithelium, especially of the Zellschicht. And in many villi one sees a thicker or thinner layer of canalized fibrin, lying between the syncytial layer and the stroma. As the change becomes more marked, the syncytial layer is likewise converted into canalized fibrin, which eventually may even invade the stroma. Large quantities of this tissue are always present on the fetal surface of the chorionic membrane, especially where it takes part in the formation of the placenta, and plays an important part in the formation of placental infarcts.

The formation of canalized fibrin and infarcts is

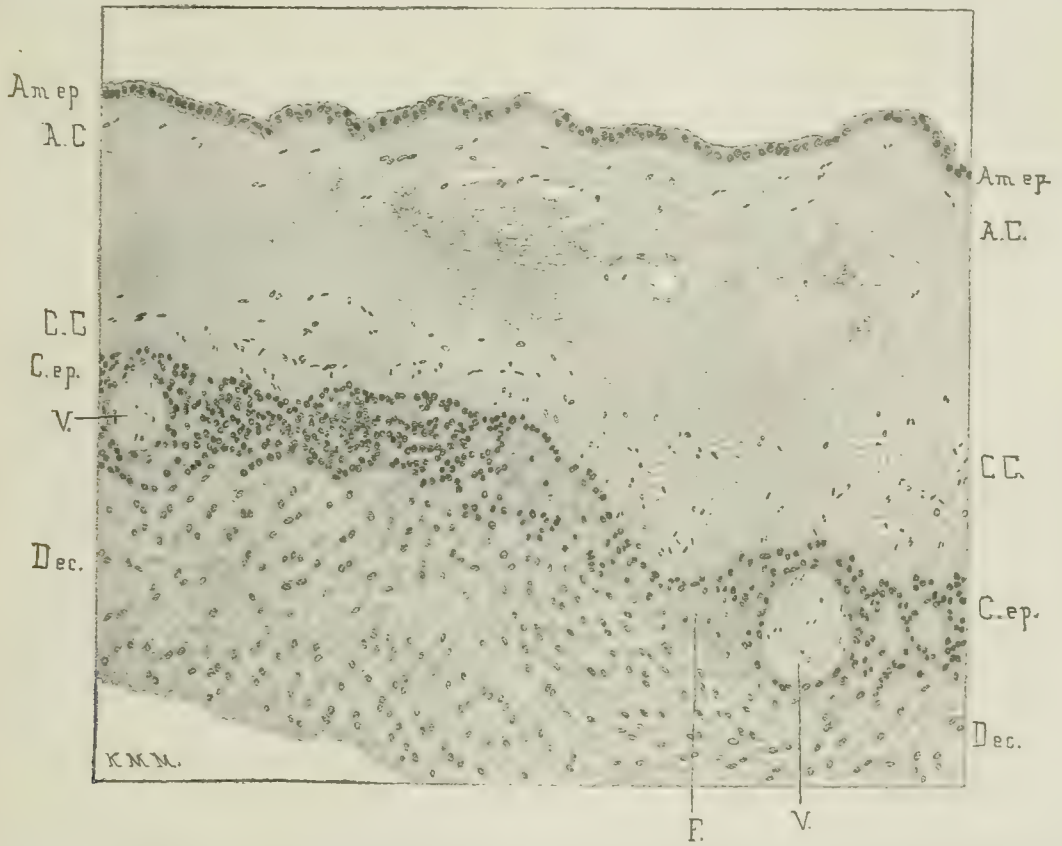


Fig. 1378.—Section through Fetal Membranes and Decidua at Term, Outside of the Placental Site. (After Williams' Obstetrics.) Magnified 77 times. *Amep*, Amniotic epithelium; *AC*, amniotic connective tissue; *CC*, chorionic connective tissue; *Cep*, chorionic epithelium; *V*, degenerated villi; *F*, fibrin; *Dec*, decidua.

usually associated with more or less endarteritis of the villous vessels, and is to be regarded as a sign of senility of the placenta. It occurs so frequently that it should be described as one of the normal constituents of the chorion. Similar changes are observed in the chorion læve, and it is probable that the degeneration of its villi is brought about in an identical manner.

In the early weeks of pregnancy, only a small portion of the cavity of the chorionic membrane is occupied by the embryo and the amnion (see Figs. 1371 and 1372). This rapidly changes, however, and in a short time the amnion increases so rapidly in size as to line the entire interior of the chorion, so that the connective-tissue layers of both membranes lie in close contact. They do not appear to become organically united, as they can be readily separated in the full-term placenta after birth.

The chorionic ectoderm also plays a rôle in the pathology of pregnancy. Hydatidiform mole is a cystic degeneration of the villi, for which alterations in the chorionic ectoderm are primarily responsible. In this condition, as was first pointed out by Marchand, the initial lesion consists of an overgrowth and irregular arrangement of the Zellschicht and syncytium. Similarly the histological elements of chorioepitheliomata are derived from fetal ectoderm. In these tumors it is generally possible to recognize both individual cells, corresponding to the Zellschicht, and masses of syncytium. For a detailed description of these pathological subjects the reader is referred to the articles on hydatidiform mole and chorioepithelioma.

J. Morris Slemons.

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**Chorion, Pathology of the.**—The pathology of the chorion remains at the present day largely an unknown field. Owing to the change of view regarding many of the conditions of the membrane formerly considered as pathological, but which are now looked upon as being only an expression of the senile decay of the organ, the known pathological conditions of the placenta have been brought within very narrow limits. It must be emphasized in this connection that the placenta is a temporary structure, and at time of delivery represents a senile, worn-out organ whose tissues are in an advanced stage of senile or physiological degeneration. These degenerative changes have in the past been looked upon as pathological and their true significance misunderstood. Having been interpreted as evidences of disease, serious misconceptions have crept into pathology regarding these purely physiological changes, and as a result the study of placental pathology has been greatly retarded. The majority of the conditions of the chorion described in the text-books as pathological, such as calcification, fatty change, sclerosis of the chorionic vessels, infarction, etc., are no more pathological than are the atrophy and sclerosis of old age, and should be regarded as possessing a similar significance. On the other hand, the peculiar pathology of the placenta—the causes of abortion, death of the fetus, the part which the placenta plays in the transmission of disease, etc.—remains at the present time a relatively little explored field.

Circulatory Changes.—It is impossible with our present knowledge to say to what extent the disturbances of the chorionic circulation are pathological. General hyperemia and anemia of the chorionic vessels are essentially dependent upon similar conditions in the fetal circulation, but the conditions of pressure to which the placenta is subjected during delivery make it impossible for us to judge accurately of the former blood content of the organ. Though the placental end of the umbilical cord is usually ligatured, and the blood in this way retained in the chorionic vessels, the pressure of the uterine contractions during delivery will have materially altered the amount of blood in these vessels, even to such an extent that a previously existing hyperemia may have been made to disappear entirely. On the other hand, if the placental end of the cord is not ligatured the chorionic vessels may be rendered anemic through hemorrhage from the severed umbilical vessels. A general hyperemia of the chorion may be caused by disturbances of circulation in the body of the fetus, stenosis of the umbilical vein through thickening of its wall, twisting of the cord, etc. General anemia of the chorion may be due to general anemia of the fetus, stenosis of the umbilical artery, twisting, knotting of the cord, etc. Local hyperemia of the chorionic villi may be caused by some obstruction to the onward flow in the veins of the chorionic stems, or may be collateral, dependent upon some neighboring anemic area. Local anemia of the vessels of the villi may be caused by pressure, obstruction of the larger arteries in the chorionic stems through thrombosis, sclerosis of the vessel walls, etc. As a result of thrombosis of the maternal sinuses a portion of the intervillous spaces may be deprived of maternal blood. The empty spaces collapse, the villi are pressed closely together, and as a result of the intraplacental pressure the vessels of the tightly packed villi become emptied of blood, giving rise to pale pinkish areas which have been regarded as infarcts. Necrosis of the villi (infarction) may result from any severe degree of anemia. In the case of twins arising from one ovum marked disturbances in the chorionic circulation may arise from the abnormal relations of the umbilical vessels. If one-sided hydramnion is also present the disturbance of the umbilical circulation may be very severe.

In general hyperemia of the placenta the organ is deep red, swollen, bleeds freely when cut, and is of softer consistence than normal. Local areas of

hyperemia are deep red to black in color, and are frequently mistaken for hemorrhage. In general anemia the placenta is pale, smaller than normal, and of firmer consistence. Localized anemias appear as pale, pinkish, or white areas.

*Hemorrhage.*—Though hemorrhage from the maternal portion of the placenta is one of the most important pathological conditions of the organ, the escape of blood from the chorionic vessels is of very rare occurrence. Hemorrhage of the fetal placenta has been very frequently described in the literature, but as the majority of these descriptions have been based upon the gross appearances alone, they cannot be accepted as conclusive. The term "placental apoplexy" has been applied to the circumscribed collections of fibrin and red blood cells so frequently found in the chorion, which from their occurrence in almost every ripe placenta can hardly possess a pathological significance. To the naked eye these appear as larger or smaller areas, deep red or black in color, of a firm consistence, and on section usually slightly elevated above the cut surface of the organ. They are found in greatest number near the maternal surface, but are also of frequent occurrence in the central portion of the organ, and at times extend entirely through it. On microscopical examination they consist of blood clots lying in the intervillous spaces. The blood may be freshly coagulated, or large masses of laminated or hyaline fibrin enclosing degenerating red blood cells may be found in the spaces between the villi. The clot may be so large as to compress the neighboring villi or to separate the chorion either partly or entirely from the maternal portion of the placenta. The blood in these cases of so-called "placental apoplexy" is of maternal origin, and since the blood is in the intervillous spaces which are themselves blood-vessels, it is not proper to consider this condition under the head of apoplexy or hemorrhage.

Numerous theories have been advanced to explain this condition, but none has proved satisfactory. Bustamente held that it is probably due to the occurrence of hemorrhage into a beginning infarct formation, the extravasation occurring into spaces bounded by necrosing villi instead of into the normal intervillous spaces. It is, however, more probable that the process is essentially a thrombosis beginning in the maternal vessels, and spreading thence into the intervillous spaces, involving a smaller or larger portion of the placenta. The majority of the cases described in the literature as hematoma of the placenta are, from their descriptions, evidently cases of infarction. Organization and encapsulation, calcification, liquefaction with cyst formation have been reported to occur as sequelæ of placental hematomata; but these were probably cases of infarction. The causes ascribed are varied: trauma, congestion, albuminuria, slow thrombosis of the maternal sinuses, excessive heart's action, etc. As a result of large hematomata the number of villi destroyed may be so great as to cause asphyxiation of the fetus. True hemorrhage from the maternal sinuses does occur, and large extravasations may burrow downward through the decidua and escape from the uterus. Since in these cases the hemorrhage is of maternal blood, serious symptoms may be produced in the mother. Decidual hemorrhage plays also an important rôle in the production of abortion.

Rupture of the umbilical vessels or of the larger branches of the chorionic stems may lead to the production of true chorionic hematomata between the amnion and chorion. Death of the fetus and abortion result if the hemorrhage is at all large. In some instances the hematoma may contain all of the blood of the fetal body, the fetus having bled to death into its own structures. Small hemorrhages from the capillaries of the villi into the chorionic stroma are occasionally seen. They are most probably dependent upon the changes in the walls of the chorionic vessels, or in many cases may be due to uterine contractions.

*Edema.*—Edema of the entire placenta occurs in retention of the dead fetus and in connection with general anasarca of the fetus caused by cardiac or renal disease, obstructions to fetal circulation, hydramnios, fetal leukemia, etc. The placenta is swollen, boggy, and lighter in color, and tears very easily. The infiltration may be so great that fluid exudes when the organ is cut. The connective tissue of the villi is separated by the fluid, and the syncytial cells may contain large vacuoles. Hydramnion is usually associated with placental edema, but the etiology is still obscure.

*Thrombosis.*—Fibrin, in the form of hyaline masses staining bright-red with eosin is always present in the intervillous spaces of the chorion from the second month, increasing in amount toward the end of pregnancy. Not all of this so-called "hyaline fibrin" gives the fibrin reaction with the Weigert fibrin-stain and these hyaline masses often appear to be made up of blood-platelets or agglutinated red blood cells. These fibrinous and non-fibrinous masses probably owe their origin to the occurrence of degenerative changes in the syncytium whereby its coagulation-inhibiting power is lost, but may also be produced by changes in the maternal blood (infections and intoxications). It is difficult to determine just when these intervillous thrombi take on pathological significance, but they are more frequent in syphilis, malaria, etc. While thrombosis is of very frequent occurrence in the intervillous spaces, it occurs much less frequently in the chorionic vessels. In both places it is in the majority of cases to be considered as a physiological process, a part of the means by which the placenta is freed from the uterus. By some writers the placental "infarct" is regarded as a thrombosis of the intervillous spaces primarily, the degenerative changes in the villi being secondary to the coagulation. Thrombosis of the chorionic vessels is one of the causes of placental infarction. It is directly dependent upon the senile changes in the walls of the chorionic vessels, which are of the nature of an obliterating endarteritis. If the thrombus is formed some time before the completion of term, it may become organized or undergo calcification. Early or excessive thrombosis must be regarded as pathological, but the conditions leading to this are not yet clear. Syphilis, maternal cachexias due to nephritis and other conditions, appear to be associated with more extensive thrombosis than is found in the chorion of normal placentas. It is probable that any thrombosis of the chorionic circulation before the beginning of the seventh month of gestation must be regarded as pathological. In the case of the physiological thrombosis occurring after this time the obliteration of the affected vessels is, in the first place, due almost entirely to the proliferating endarteritis, the obstruction being completed by the thrombosis. Following the obliteration of the main chorionic branch, there is a progressive thrombosis of the smaller arterioles, capillaries, and veins belonging to it. As a result of the shutting-off of the blood supply to the villi there follow marked degenerative changes in the structures of the villi which will be described under the head of infarction. Agglutination-thrombi may be formed in the chorionic vessels as the result of infection or intoxication, as in the case of tuberculosis of the placenta, in which agglutination-thrombi containing tubercle bacilli may be found in the larger chorionic vessels.

*Infarction.*—The so-called anemic or white infarct of the placenta is one of the oldest described conditions of this organ. In the beginning mistaken for inflammation of the chorion, the history of the placental infarct and that of placentitis are for the greater part identical. Guillemeau in 1648, Mauriceau, Portal, and Morgagni a little later, were the first to note the occurrence of placental infarcts, but interpreted them

as being inflammatory in nature. Later the same appearances of the placenta were accorded a great variety of interpretations, such as atrophy, hepatization, phthisis, apoplexy, hematoma, fatty degeneration, hyalin, amyloid, gumma, etc. In recent years the minute changes underlying the gross appearances have been more clearly understood, and the present tendency is to consider them in the light of an anemic necrosis dependent upon senile changes and having a physiological significance.

To the naked eye the infarcts of the placenta appear as yellowish-white or red areas, more or less sharply outlined, firm in consistence, and lacking the usual

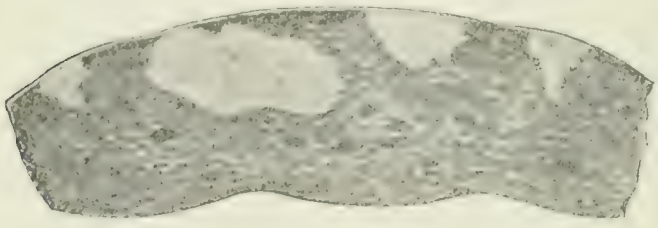


Fig. 1379.—Placental Infarction. Natural size. (After Kaufmann.)

spongy appearance of placental tissue. They vary greatly in their location and size. They may be very large, involving several cotyledons or even half or two-thirds of the placenta. Usually they are of small size, varying from areas just visible to the naked eye to wedge-shaped or irregular areas several centimeters in diameter. They occur most frequently just beneath the fetal and maternal surfaces of the organ, but may extend entirely through it. Not infrequently they form broad or narrow bands lying upon the surface of the chorion just beneath the amnion. These bands are usually but a few millimeters in thickness. They may occasionally run around the margin of the placenta (placenta marginata), or they may form a zone around the center of the organ some distance from its periphery (margo placentæ), being separated from its edge by apparently normal tissue. In other cases red or yellowish areas are scattered through the substance of the organ and are discovered only when the placenta is cut. The red infarcts may vary in color from a pale pink to black. They occur most often upon the maternal side, but may extend completely through the organ. To these red areas the term "placental apoplexy" has been usually applied.

The red infarct may be elevated above the surface of the placenta, and in some cases the organ may be studded with small dark-red nodules (placenta truffé). The yellow or white infarct is more often depressed, and when of large extent may cause furrow-like depressions over the placental surface. On section the light-colored infarcts have a more or less fibrillated or laminated structure, but frequently appear cheesy. The red ones have a more granular surface. Calcification occurs with great frequency in the infarcts of all colors.

Microscopically the infarct consists of chorionic villi more or less necrosed and compressed together, surrounded by fibrin, red blood cells, and necrosing decidual septa. The nuclei of the connective-tissue cells of the villi have either entirely lost their chromatin or are disintegrating, the villous elements becoming fused into a hyaline mass, taking a uniform pink stain with eosin. The syncytial cells are partially desquamated and fused into black-staining masses of chromatin, while the cells of the decidual septa between the villi are swollen, vacuolated, and exhibit various stages of necrosis. Fibrin is deposited upon and around the villi, and is made up of closely packed fibrillæ so that it appears almost hyalin. It stains with Weigert's fibrin stain in the same manner as does fibrin found elsewhere.

In other cases the infarct consists only of large masses of laminated fibrin in which no traces of villi can be found. Others contain shadows of necrosed villi, and between the infarcts containing no villi and those exhibiting necrosing ones every stage of transition may be found. Those consisting only of fibrin are probably to be regarded as older infarcts. In the fibrin masses degenerating red cells are found in large numbers, and not infrequently there is a well-marked infiltration of leucocytes into the fibrin. Lime salts may be deposited in the dead villi, the syncytial cells, or the necrosing decidual cells, or in the fibrin. Fatty degeneration of the necrosing villi is rare. In large infarcts a liquefaction or simple softening of the central portion may take place, resulting in the formation of a pus-like fluid, which may lead to an incorrect diagnosis of abscess of the placenta. As a rule, the villi immediately bordering upon the infarct show no change, but occasionally there may be a sequestration of the infarct, or formation of a connective-tissue capsule about it. Rarely a leucocyte infiltration is seen about the infarct.

In small infarcts the changes are not so marked, and the villi (one or several in number) may be but slightly changed, and surrounded by a narrow ring of hyaline fibrin. The syncytium usually shows some evidence of necrosis or desquamation, but the stroma of the villus may remain unchanged. The structure of the surface and central infarcts is essentially the same. The large pink infarcts are similar to the white ones except in the fact that the red blood cells are preserved. The red infarcts may present a microscopical appearance exactly similar to that of the white ones. In other cases the fibrin composing

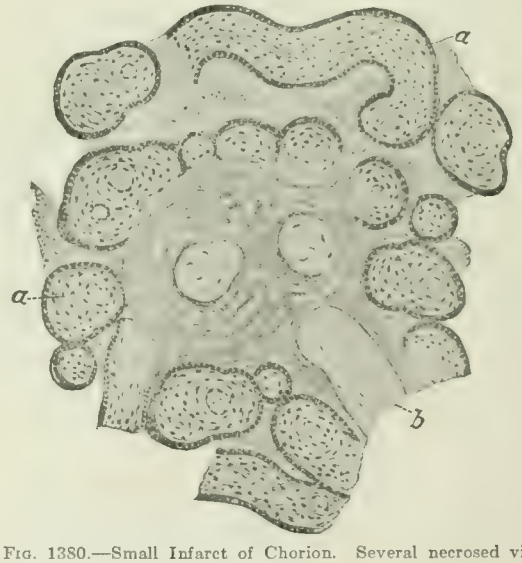



Fig. 1380.—Small Infarct of Chorion. Several necrosed villi surrounded by fibrin. The necrosed villi have lost their syncytial covering. (After Kaufmann.)

them contains many red cells. Non-fibrinous infarcts may also occur, to the naked eye resembling the white fibrinous ones, but microscopically consisting of necrosed villi crowded closely together without intervening fibrin. Eden believes that these are caused by the shutting off of the blood in the decidual sinuses whereby the supply to the intervillous spaces is obstructed. These, being no longer filled with blood, collapse, and the villi being thus closely crowded together, become anemic and undergo necrosis.

The larger blood-vessels of the chorionic stem to which the infarcted villi belong, show, as a rule, a well-marked obliterating endarteritis and periarteritis associated with thrombosis, and it is probable that the infarction is due to these conditions.

While there is among recent writers a universal agreement as to the minute structure of placental infarcts, there is still some diversity of opinion as to their etiology and pathological significance. Three views obtain. One holds that infarcts are the result of degenerative changes occurring in the decidua and extending thence to the neighboring villi, the intervillous fibrin masses representing degenerated decidua. Proliferation of the decidua may even first take place. The changes in the chorionic vessels are regarded as purely secondary. The second view holds that the vascular changes in the chorion are primary, and that as a result of these, necrosis of the villi occurs followed by the deposition of fibrin upon and about the dead villi. The third view is that the infarct is a *primary hematogenous thrombosis* of the intervillous spaces resulting from the slowing of the blood stream and changes in the chorionic epithelium whereby it loses its power of inhibiting coagulation. The degenerative changes in the villi are regarded as secondary to the thrombosis. According to Hitschmann, Lindenthal, Schickele and Kaufmann the designation of *thromboses* or *fibrin nodules* is preferable to that of infarcts.

That the so-called infarct is a physiological process within certain limits we must conclude from the fact that it occurs in numbers in every mature placenta. Delore, in 1899, found in the examination of several thousand cases that infarcts occurred in one hundred per cent. Williams, in 1900, states that he has found infarction in greater or less extent in every full-term placenta examined. The writer in an examination of one hundred successive placentas found them in every case. Many of the older writers at widely separated periods of time expressed the belief that infarcts (described under various heads) were found in the majority of all placentas. Eden was one of the first of the more recent writers to emphasize the constant occurrence of placental infarcts as being of a physiological nature and not as evidence of disease. His views have recently been confirmed by Williams and others.

According to Ackermann, Eden, and Williams, the chief factor in the production of placental infarction is to be found in the changes occurring in the chorionic vessels. These are of the nature of an obliterative endarteritis and periarteritis, and are usually most marked in the vessels of the chorionic stems and in the larger arterioles of the villi. The degree to which this change occurs varies greatly; in many cases the lumen of the vessel may be almost or entirely obliterated, while in others there is but a slight thickening of the intima. The endarteritis is similar to that found in other regions of the body; there is a proliferation of the subendothelial connective tissue with resulting narrowing of the lumen, the newly formed tissue becomes hyaline and gradually loses its nuclei. There may or may not be an increased number of wandering cells in the vessel wall. Calcification occurs much less frequently than in sclerotic vessels in other parts of the body.

These sclerotic changes occur in all healthy placentas; their etiology is unknown, but inasmuch as they form a part of the life history of the organ, the causes leading to their production must be sought for in the operation of the general laws of histogenetic development and decay. Under ordinary conditions, to be regarded as an expression of senile degeneration, these vascular changes can come to have a pathological significance when they appear at an earlier period than normal. In such case they are to be taken as an indication of premature senility.

As a result of these vascular changes disturbed nutrition of the tissues of the villi occurs. This is shown in the first place by a necrosis of the cells lying just beneath the syncytium. This leads gradually to a desquamation of the syncytial layer. Changes in the chromatin of the syncytial cells take place but slowly, leading to the inference that these cells may derive some nourishment from the maternal blood. They do not begin to degenerate until the tissue beneath has reached a certain degree of necrosis. As the process advances the connective tissue of the villus undergoes necrosis, becoming changed into a hyaline mass which stains deep red with eosin. The necrosis of the surface of the villi is of the nature of a coagulation necrosis; fibrin is deposited upon the dead cells. As the process advances larger pieces of syncytium degenerate, and upon these dead cells there is deposited a thick layer of hyaline fibrin which binds the dead villi together in a firm fibrinous mass. In the oldest portions of the infarct the villi gradually lose their contour, the central portion of the infarct becoming after a time an indistinguishable mass which may either liquefy or undergo calcification. The syncytial cells may be preserved for a long time in the meshes of the fibrin, appearing as deeply staining clumps of chromatin.

According to Williams, the death of the stroma of the villus is also of the nature of a coagulation necrosis by which the tissue of the villi becomes changed into canalized fibrin. The writer, in the study of a large number of infarcts, has never seen anything warranting the belief that fibrin may be formed from necrosing stroma of the villi. While the dead villi stain similarly to fibrin with many stains, the proper management of Weigert's fibrin stain will always differentiate between the dead villi and the true fibrin derived from the blood elements.

While some placental infarcts are undoubtedly due to the vascular changes in the chorion, it seems possible that in certain cases the infarction is the result of changes beginning in the so-called decidual septa which extend into the chorion. Eberhardt, Williams, and others believe that these septa are of ectodermal origin and not maternal. If this is the case the primary factors in the production of infarction are to be sought always in fetal structures. On the other hand, Steffeck and others hold that infarction is always of maternal origin, the primary change taking place in the cells of the septa, the latter being extensions of the maternal decidua into the chorion. The necrosis of these cells leads to the formation of fibrin in the intervillous spaces which contracting compresses the villi and so leads to their necrosis.

Hitschmann, Lindenthal, Kaufmann, and others regard the vascular changes as having no etiological relation to the formation of the intervillous thrombi or "infarcts." Degenerative changes in the syncytium they consider to be the primary cause, but give no explanation of the cause of these changes. As already pointed out degeneration and necrosis of the syncytium may be due directly to the vascular changes. Kaufmann, however, holds that there is no constant relationship between the vascular changes and infarction, that the latter occur when there are no arterial changes, and that obliteration of the chorionic arteries does not always lead to infarction. While these questions are far from being settled, it seems most probable that a number of factors, such as changes in the maternal blood, syncytium, or blood-vessels, may lead to intervillous thrombosis and the formation of infarcts.

The pink infarcts do not differ in their etiology from the white ones, but are most probably to be regarded as more recent infarcts, the blood between the necrosing villi having undergone but imperfect coagulation. The large dark-red infarcts commonly regarded as "placental apoplexy" are due to

dilatation and thrombosis of the intervillous spaces, and are not hemorrhages. Their etiology and significance are not yet known, but it is probable that they are connected with the thrombosis of the maternal sinuses which gradually extends into the intervillous spaces involving a larger or a smaller portion of the placenta. The origin of the non-fibrinous infarcts is probably that suggested by Eden, as mentioned above.

As sequelæ to infarction there may result a gradual atrophy or absorption of the dead villi and fibrin, simple softening with formation of a pus-like material, calcification, or in rare cases organization may lead to the formation of a fibroma-like mass of connective tissue. Chorionic cysts may also be formed by the liquefaction of the central portion of an infarct.

The sclerotic changes in the chorionic vessels and the resulting infarctions must be considered as purely physiological processes in the great majority of all full-term placentas. Unfortunately, the significance of these conditions is at the present time but little understood, and consequently normal phenomena have been accorded the most varied pathological interpretations. Such mistakes are due entirely to a lack of familiarity with the changes found in normal placental tissue. In all healthy placentas infarcts are constantly found, and are present at all stages of gestation from the earliest period of chorionic development. A progressive atrophy and disappearance of the villi in the chorion læve occur from the very beginning of placental formation, and this is the normal way in which the extraplacental villi are disposed of in the earlier weeks of gestation. In the fetal placenta itself from the very beginning there is on one hand a progressive formation of new villi and a progressive destruction of the older. This process is but the extension of that from the extraplacental chorion, and a definite progression can be traced between the infarctions of the extraplacental villi and those of the placental chorion. As Eden has pointed out, infarction is therefore "not the result of pathological factors but forms a part of the normal life history of the placenta, and its etiology is to be looked for in the operation of the natural forces of evolution and decay."

Yet many authors seek to give a pathological meaning to the infarcts found in the full-term placenta. Von Franqué holds that the vascular changes in the chorionic vessels are pathological and lead to placental edema, excess of the amniotic fluid, etc. Cohn, Wiedow, Martin, Pinard, and others believe that there is some definite relation between maternal albuminuria and placental infarction, and that the latter process leads to marked changes in the condition of the fetus even to the extent of death and abortion. Kaufmann places endometritis and nephritis above all other things as etiological factors in infarction. A relation has also been claimed to exist between infarction and eclampsia. Zilles, Prinzing, Orth, and others believe that there is a causal relation between syphilis and infarction. Favre, Martin, and Delore hold that infarcts are caused by the presence of bacteria in the blood of the intervillous spaces, that these cause degeneration and necrosis of the syncytial cells which in turn lead to infarction. Williams examined twenty placentas bacteriologically and found the infarcts to be sterile. The latter writer holds that moderate infarction is not pathological and exerts no harmful influence upon either mother or fetus. Marked infarction he believes to be associated usually with maternal albuminuria, and often results in the death or imperfect development of the fetus.

According to the results of the writer's study of many hundred full-term placentas, large infarctions may be found in cases in which there was no albuminuria and in which both mother and child were apparently normal. Such infarctions are, however, of greater frequency in the placentas from mothers suffering from cachectic conditions of all kinds, tuberculosis, syphilis, severe chronic malaria, nephritis, anemia, severe endometritis, etc.; and it is probable that in such conditions the infarct acquires a pathological rôle and may affect the development of the fetus. Especially is this likely to be the case when large infarctions occur in the early months of gestation. The occurrence of large infarcts before the seventh month seems to be especially associated with syphilis and pernicious malaria. The significance of chorionic infarction may then be summed up as follows:

1. Moderate infarction of the placenta after the seventh month is physiological. It increases in number and degree with the age of the placenta, and is to be considered as one of the signs of maturity. In "over-time" placentas the amount of infarction is often very considerable.

2. Marked infarction of the ripe placenta may have apparently no pathological significance, but is sometimes associated with maternal cachexias and may affect fetal development.

3. Marked infarction of the placenta in the earlier stages of gestation is especially associated with syphilis, tuberculosis, and nephritis of the mother, and may result in abortion.

Atrophy.—There is in the fetal placenta from the very beginning of its development a progressive atrophy of the chorionic villi on the one hand, and a new formation on the other. The superfluous villi of the chorion læve undergo a simple atrophy, and the process extends from them to the placental chorion. At term the villi are, as a rule, of much smaller size than in the early months, and this decrease in size is to be looked upon as being of the nature of a histogenetic or senile atrophy. The myxomatous tissue of the young villi takes on with age somewhat of the character of mature connective tissue, and while many of the villi never lose entirely their embryonic character, their interstitial tissue becomes firmer and more compact, and contracting causes a marked decrease in size. The small vessels of the villi are, however, not affected by this contraction; on the contrary, they become relatively much larger. If these atrophic changes occur to any great extent before the seventh month they must be regarded as pathological. Premature atrophy may be due to syphilis, or to marked cachexias due to other causes. The direct cause of both physiological and pathological atrophy lies in the sclerotic changes in the larger chorionic vessels. Slow obliteration of these vessels leads to simple atrophy of the villi, while a more rapid shutting-off of the circulation leads to infarction. The first structure of the villus to show signs of atrophy is the deep layer of the chorionic epithelium. In the young placenta the epithelial covering of the villi consists of two layers: a superficial layer of nucleated plasmodium, and a deep one of well-defined nucleated cells. After the third month this deeper layer undergoes atrophy so that in the ripe placenta it has almost entirely disappeared, being represented only by scattered nuclei beneath the plasmodial layer. The plasmodial layer undergoes a similar atrophy in the last months of gestation. In the ripe placenta many of the villi show in places complete atrophy of the syncytium, so that underlying capillaries may be directly exposed to the maternal blood. In other villi the syncytial layer shows marked pyknosis. The loss of vital energy in the syncytium is further shown in the last two months by the gradual cessation of bud and process formatiom whereby the development of new villi comes to a standstill. The changes in the stroma occur at the same time with those in the syncytium. Fibrin is never deposited upon villi showing simple atrophy alone, but only upon those showing necrosis or degeneration.

Necrosis.—Necrosis of the syncytial layer is always present in the mature placenta in a certain number of the villi, as shown by pyknosis and desquamation. Within certain limits these changes are physiological. They are increased in certain infections and intoxications (syphilis, nephritis, malaria, etc.). Necrosis of the villi occurs in infarction as described above. It is usually of the nature of a simple necrosis, but many writers regard it as being a form of coagulation necrosis. The stroma just beneath the syncytium is the first part affected; its nuclei become swollen, irregular in shape, and there is a gradual loss of chromatin. The syncytium then necroses and fibrin is deposited upon the dead surface of the villus. The formation of fibrin from the degenerating structures of the villus, as claimed by Williams and others, is not yet an established fact. Necrosis of the villi occurs also in retained placenta after the birth of the fetus, after abortion, or in connection with a retained dead fetus. Infection with putrefactive organisms may occur, and moist gangrene result. In a number of cases gaseous emphysema of the necrosing placenta has been observed, and the *Bacillus aërogenes capsulatus* was found to be present both in the fetus and in the placenta. The sequelæ of necrosis of the villi are the same as those given under infarction.

Cloudy Swelling.—Preceding the necrosis in infarction there is a stage of degeneration in the syncytial and subsyncytial cells which is analogous to the cloudy swelling of parenchymatous organs. The cells become swollen, their nuclei larger, the cell outline irregular, and there is a gradual disintegration of the chromatin. Such changes are very commonly found throughout the entire placenta in retention of the organ after abortion, delivery, or in connection with death of the fetus.

Hydropic Degeneration.—This occurs in edematous placentas, in necrotic placentas retained after abortion or delivery, in gangrene, placental inflammation, acute and chronic hydramnios, hydatid moles, and in the chorionic villi of ectopic gestation. The villi showing this degeneration contain large vacuoles throughout their stroma. Vacuoles may be found also in the syncytium and in the cells of Langhans' layer.

Fatty Degeneration.—A very slight degree of fatty degeneration of the villous stroma must be looked upon as a normal condition in the last months of pregnancy. Extensive fatty degeneration of the placenta was first described by Barnes, but there can be no doubt that the changes which he saw were those of infarction. As the result of his error the literature from 1851 to 1890, both in England and in this country, contains numerous reports of fatty changes of the placenta based upon the gross appearances, and the descriptions in all of these cases correspond to the gross changes seen in infarction. Marked fatty degeneration of the villi is very rare, and is confined almost entirely to the villi in ectopic gestation after the death of the fetus, but the degeneration occurs to a lesser degree in placentitis, infarction, retained placenta, etc. The whole question of the fat-content of the placenta has recently been studied by Bondi (*Arch. f. Gyn.*, B. xciii., 1911). He concludes that fat-droplets occur regularly in the syncytial cells, in typical arrangement around the nuclei. The amount of fat is greatest in the earliest months of pregnancy, and becomes less toward the end. In the chorionic stroma there is little fat during pregnancy. It appears increased after the death of the fetus. The placental fat-content is independent of the nutritional state of the mother or the fetus. The chorionic syncytium has no part in the fatty degeneration of phosphorous or phloridzin poisoning. Fatty degeneration is not present in the normal regressive metamorphosis of the syncytium. The fat of the placenta is a resorption fat, brought to the fetus by the blood for its use, and is passed by the fetal circulation into the body of the fetus for its metabolism.

Glycogen.—According to Driessen glycogen is never found in the fetal portion of the normal placenta, the decidua cells alone showing it, and from these cells it disappears as pregnancy advances, the glycogen-content of the decidua cells being greatest between the third and eighth weeks. In the mature placenta only occasional decidua cells show its presence. Iodyo (1912) finds glycogen in all parts of the placenta, most abundantly in the first two months lessening toward maturity, but always present to some extent. In the early months it is found in the syncytium, later chiefly in the connective tissue and blood-vessel walls of the villi.

Myxomatous Degeneration.—The stroma of the chorionic villi and also of the chorionic stems is during the early months of pregnancy of the nature of myxomatous tissue. In the later months it takes on more of the nature of mature connective tissue, especially in the stems, where it comes to resemble fully developed fibrous connective tissue. Many of the villi, however, never entirely lose their embryonic type. In some cases the entire chorion may retain the character of myxomatous tissue, in other cases there is a myxomatous degeneration of the mature connective tissue of the stems and larger villi. This is not uncommon in placenta prævia. This degeneration occurs in the placentas of cachectic individuals and in retained placentas after delivery at full term. Associated with a persistence of embryonic type or with a myxomatous degeneration there may be a hyperplasia of the chorion which gives rise to the condition known as vesicular mole, hydatid mole, etc. (see below).

Hyalin.—Within certain limits a hyaline change in the walls of the blood-vessels of the chorionic stems is physiological in the ripe placenta. Early or excessive change of this nature must be regarded as pathological. This occurs in the pre-senile condition caused by syphilis, malaria, nephritis, and other cachexias.

Amyloid.—The presence of amyloid in the chorion has been reported a number of times, but it is highly probable that the changes seen were those of infarction, and that hyaline fibrin was mistaken for amyloid.

Calcification.—The deposit of lime salts in the chorion is also within certain limits to be regarded as a senile process. Small areas of calcification are very common in the ripe placenta, occurring practically in every one, and are entirely without pathological significance. The deposits may be scattered throughout the chorion, as many as five hundred concretions having been found in one placenta, or the entire surface of the chorion beneath the amnion may be covered with a calcareous deposit. In the latter case the deposit is found in the layer of fibrin lying between the amnion and the chorion. In the scattered deposits the calcification occurs chiefly in the intervillous fibrin masses, but may be found in any portion of the chorion, in the syncytial layer, the connective tissue of the villi, or in the walls of the blood-vessels of the chorionic stems. The deposits occur most frequently in or about areas of infarction. They are usually of small size. To the naked eye the presence of calcareous masses in the placenta is shown by whitish areas having a firm consistence, a gritty feel, and giving a grating sound when struck with a knife. Microscopically the deposit consists of irregular masses of calcium carbonate, or phosphate, or magnesium phosphate, giving the characteristic staining reaction with hematoxylin.

Just when calcification takes on a pathological significance it is at present impossible to say. Ex-

tensive deposits may occur when both mother and child are apparently in perfect health. On the other hand, it has been claimed that calcification to an extensive degree is associated with syphilis and death of the fetus, but no constant association can be shown to exist. In placentas before the seventh month calcification has the same significance that infarction or sclerosis has at this period; it is to be taken as an evidence of premature senility, and dependent upon nutritional changes resulting from syphilis, tuberculosis, or other cachectic conditions. In both syphilis and nephritis a fatty degeneration of the terminal villi may precede the calcification. Early infarction dependent upon early obliteration of the chorionic vessels is almost always followed by calcification if the nutritional disturbances are not so great as to produce abortion. Syphilis is the most commonly associated condition, and may therefore be regarded as an etiological factor. The writer has also seen extensive calcification of the placenta in two cases of pernicious malaria. In both cases the six-months placenta was fibroid, showed no proliferation of the villi and presented in all parts extensive deposits of lime salts. Since calcification most frequently follows infarction, the greater the number of infarcts the more extensive the calcification. It may therefore be taken to a certain extent as an expression of the degree of senile change, but it must be remembered that in many cases infarction is not followed by any deposit of lime salts. In the retained placenta, either after delivery or after abortion, calcification is of very frequent occurrence. It is also very frequently found in the chorion in ectopic gestation. Both membranes and fetus may be entirely calcified (lithopedion). On the other hand, sclerosis of the chorionic vessels is but rarely followed by calcification of the vessel wall.

Pigmentation.—Pigmentation of the chorion is very rare. Hematoidin and hemosiderin may be found in old infarcts, but, as a rule, these pigments are not formed in the placenta from the disintegration of the red cells. They are of more frequent occurrence in retained placentas. In malaria of the mother the blood in the intervillous spaces contains both the malarial organism and its pigment. The latter may be deposited upon the surface of the syncytium, but does not pass through this layer. Retained placentas in cases of severe icterus of the mother become stained with bile pigment, the pigmentation being confined to the syncytial layer except in those portions of the villi denuded of syncytium where the stroma of the villus is also bile stained.

Fibrinoid Degeneration.—Much has been written upon the origin of placental fibrin, and the subject cannot be said to be definitely settled. Ackermann holds that it arises from the decidual cells and from the plasmodial and cellular layer of the villi, and not from the maternal blood. Minot also affirms that it arises from a degeneration of the chorionic epithelium. Williams believes likewise that the syncytium undergoes coagulation necrosis and is converted into canalized fibrin. Eden considers it to be largely a product of the maternal blood. The process has been styled hyaline, fibrous, fibrinous, hyaline-fibrinous, and fibrinoid degeneration of the placenta by the various authors who regard it as being of the nature of a degeneration, but who have given but little proof of their assertions. The writer, after a careful study of many placental infarcts, has been unable to convince himself that the placental fibrin has any other origin than that of the maternal blood. While with ordinary stains the intervillous fibrin has a hyaline, homogeneous appearance, indistinguishable from the necrosed syncytium and decidua, a differentiation can usually be made with Weigert's fibrin stain. When stained by this method, the fibrin always shows a reticulated structure, in the meshes of which lie necrotic cells of the syncytium and decidua. Some of the intervillous hyaline material is not fibrin, but is made up of blood-platelets or agglutinated red blood-cells.

Progressive Changes.—During the first seven months of gestation there is a constant new formation of chorionic villi. Proliferation of the nuclei of the syncytium takes place, leading to the formation of a plasmodial bud or offshoot, which becomes vascularized from the villous capillaries, and a stroma is formed for the young villus from the proliferation of the stroma cells of the parent villus. During the last two months of pregnancy the formation of the plasmodial buds continues, but very few become vascularized. The number of buds is, moreover, not so great as in the early months. In sections of the placenta these buds appear as large plasmodial giant cells when cut transversely. They are frequently very numerous around infarcts, suggesting a compensatory regeneration. Rarely the placenta at full term is increased in size, and shows active proliferation of the villi as in the early months. With this hyperplasia there may be associated a myxomatous or hydropic degeneration of the stroma of the villi, giving rise to the condition known as vesicular or hydatid mole. A similar process takes place after abortion or delivery in case the placenta is retained, but is much more frequent and extensive the earlier the death of the fetus occurs. The retained placenta, after abortion, may live with not only a lessened, but frequently an increased vitality many months after the death of the fetus, and this may lead to a hyperplasia of the villi resembling in character that of a new growth. These hyperplastic growths of the chorion may be found in all stages from the slightly increased activity in the formation of syncytial buds to the development of atypical buds infiltrating the uterus wall and producing metastases in other organs. Various names have been given to these growths, and their terminology is still confused. It is difficult to draw any close distinction between the simple hyperplasias on the one hand and the new growths on the other. For reasons of convenience they will be described under the head of tumors of the chorion.

Placentitis (Chorionitis).—Though the term placentitis occurs frequently in the literature, the actual anatomical observations of inflammatory conditions of the fetal placenta are so rare and the interpretation of these so varied and conflicting that the condition cannot be said to have a definite status in pathology. Throughout the older literature there are references to placental inflammation as an occurrence possible but rare. It is first definitely mentioned by Guillemeau in his "Oeuvres de Chirurgie," 1648. Mauriceau, Portal, and Morgagni gave clinical descriptions of "placentitis" unsupported by anatomical observations. Cruveilhier, Murat, Brachet, Stein, d'Outrepont, Wilde, Simpson, and Rokitansky made many observations by which they declared the existence of placentitis to be conclusively proved, that it was both acute and chronic in its course, and in common with other inflammations possessed three stages. The conclusions of these observers were based wholly upon the gross appearance of the organ and upon a theoretical application of the changes seen in croupous pneumonia. The modern reader can have no doubt that they saw and described the placental infarct. In 1849 Scanzoni gave a more exact description of infarction, showing that the yellowish areas consisted of fibrin. He, however, interpreted the condition as inflammatory in nature and designated it as "phthisis placentæ." He was supported in these views by Mattei and Geoffroy.

But doubt as to the correctness of these views soon arose. Verdier and Bustamente explained the phenomena as due to retrograde metamorphoses of

blood clots. Robin especially opposed Scanzoni's views, and gave the process a wholly different interpretation. According to his observations there did not exist a true inflammation of the placenta, at all events no one had yet seen it. What had been taken for placentitis he affirmed was nothing more than a "fibrous" degeneration of the chorionic villi arising from the obliteration of the chorionic vessels. Doubt as to the existence of placentitis then took a more definite form. Millet, in 1861, said: "Nothing is less precise than the symptomatology of this affection, nothing is less exact than its pathological anatomy, in a word, nothing is less proved than this inflammation itself." In 1862 Maier and Hegar studied very carefully the phenomenon formerly described as placentitis. After a minute description of the well-known appearances and structure of the white infarct, they decided that the partial necrosis of the villi near the fibrin masses was the expression of an interstitial placentitis similar in its nature to hepatic cirrhosis. Maier noted also the periarteritis of the chorionic vessels, and considered the two conditions to be closely related and to lead to the same result, atrophy and degeneration of the villi.

In 1869 Charpentier doubted very much the existence of a true inflammatory condition of the placenta. The pathological anatomy of the organ became more and more unsettled, and the disposition to reject placentitis altogether rapidly increased. Many opinions were given asserting the impossibility of a placental inflammation in the Cohnheim sense of the process, since there "are no capillaries in the maternal placenta through which a migration might take place and no nerves to regulate the contractility of the vessels throughout the organ." The opinion of Robin came to be most generally accepted: "What has been taken for inflammation of the placenta is nothing else than a condition of transformation of blood clots at different stages. What has been regarded as pus is only fibrin in the course of disorganization, and in those cases where true pus has been found the pus did not come from the placenta but from an inflammation of the tissue of the uterine walls and an accidental deposition in the tissue of the placenta."

In 1884 Ackermann declared all previously entertained views to be incorrect, and explained all of the observed phenomena on the theory of an anemic infarct of the placenta. His views were accepted by the majority of pathologists in so far as the question of the existence of placentitis is concerned. An immense quantity of literature concerning placental infarction now sprang into existence, and from 1884 to the present time the question of placental inflammation has been practically relegated to a far background. In summing up the gleanings from the literature we find that the older writers believed in the existence of a placentitis which they constructed from clinical phenomena, inaccurate gross observations, and still more inaccurate microscopical examinations and weakly grounded reasonings from analogy. As the knowledge of pathological histology developed, the status of placentitis became more and more unsettled, and the changes which the older observers looked upon as inflammatory were shown to be of the nature of infarction, and finally, in our own day, to be considered as only the expression of senile decay of the organ. The literary history of placentitis is the history of the placental infarct, and inflammation of the placenta as a definite pathological entity has almost disappeared from the later literature, and its existence is affirmed only by scattered and unsatisfactory observations.

Small foci of leucocytes are not infrequently seen in the ripe placenta, especially in the neighborhood of infarcted areas, but their significance is unknown. A true purulent inflammation of the maternal portion of the placenta is relatively common. It may be due to gonorrheal infection, or to an extension of a neighboring purulent process to the endometrium and decidua. In the earlier months it may be due to infection resulting from attempted abortion. The cells of the decidua undergo a liquefaction necrosis and there is a large leucocyte infiltration which may assume the proportions of abscess formation. The leucocyte infiltration extends along the decidua and into the decidual septa, but only in rare cases involves the chorion, the uppermost layer of the decidua apparently acting as a barrier to the extension of the process. The chorion is most likely to be involved when the decidual inflammation occurs in the early months. In such cases the syncytium becomes swollen and hyaline, gradually losing its nuclei, and taking a very deep stain with eosin, but does not give

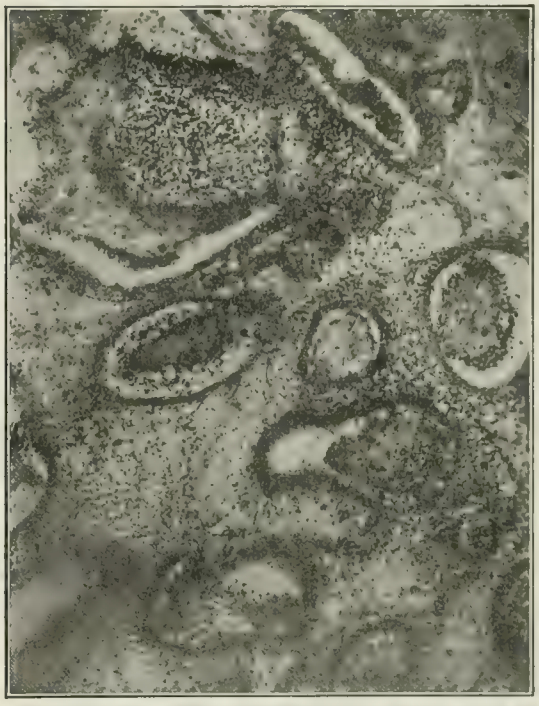


Fig. 1381.—Purulent Chorionitis: Gonorrheal Infection of a Six Weeks' Placenta.

the fibrin stain with Weigert's method. The stroma of the affected villi is partly or wholly liquefied and replaced by leucocytes. Each villus may come to have the appearance of a small abscess surrounded by the syncytium, which remains intact long after the stroma of the villus is entirely destroyed. The formation of syncytial buds may take place even at this stage. Fibrin is formed in the intervillous spaces, but is not so homogeneous and hyaline in character as in the placental infarct. Leucocytes may or may not collect upon the surfaces of the affected villi, and in the early stages of chorionitis there may be no coagulation in the intervillous spaces, even when the changes in the syncytium and stroma of the villi are far advanced. The place of extension of the purulent process from the decidual septa to the chorion may usually be discovered. Ultimately the complete destruction of the affected portion gives rise to a well-defined abscess of the placenta. Death of the fetus, general sepsis on the part of the mother, may result, or in rare cases the pus may burrow downward through the decidua, escaping from the uterus, and the gestation go to full term. Purulent inflammation of the decidua and chorion is of frequent occurrence in the retained

placenta after abortion and delivery, and in the placenta of ectopic gestation.

Interstitial chorionitis, both acute and chronic, has been described. The acute forms occur only in the early months of gestation, and are practically always due to syphilis or tuberculosis, and will be described under those heads. The cellular productive hyperplasia of the stroma of the villi is pathognomonic of syphilis. The chronic fibroid hyperplasia of the villi is caused by syphilis, malaria, and chronic intoxications; it is not a specific change of placental syphilis. Excessive calcification is very common in fibroid chorionitis.

Periarteritis, Endarteritis.—The changes in the chorionic vessels were at a very early period regarded as inflammatory in nature. As before mentioned, the present view is to consider them in the mature placenta as being of the nature of senile changes. They acquire a pathological significance only when occurring prematurely or to an excessive degree. The process begins as a rule in the terminal and medium-sized arterioles, later in the larger arteries, while the veins and capillaries are not affected until the blood supply is almost shut off by the arterial changes. The first indication of the process is shown in a thickening of the adventitia. Very soon the intima is involved, the subendothelial cells proliferating irregularly, forming localized growths into the lumen, or a more regular narrowing of the lumen as a

Fig. 1382.—Chorionic Stem from Ripe Placenta, Showing Normal Obliteration of Chorionic Arteries. Fibrin adhering to edge. Camera lucida drawing; Leitz No. 3 objective; eyepiece No. 2; reduced one-third.

whole. When the lumen is almost entirely obliterated, there is usually a loss of the endothelium and the obturation of the vessel is completed by thrombosis. In the tissue about the affected vessels there may or may not be any increase in the number of wandering cells. These changes begin as early as the seventh month and progress until delivery. They are regarded by some writers as the direct cause of infarction. The relation between the vascular changes and infarction is, however, not constant.

Syphilis.—The changes in the chorion ascribed to syphilis are numerous and varied. Infarction, fatty change, calcification, sclerosis of vessels, fibroid degeneration, interstitial placentitis, etc., have all been regarded by various authors as being of syphilitic origin. As seen above, many of these conditions are physiological within certain limits, and in the present state of our knowledge it is impossible to

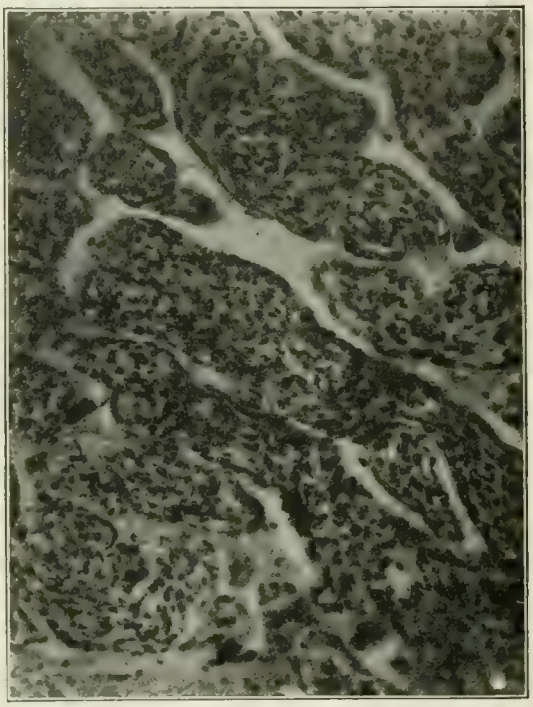


Fig. 1383.—Syphilis of the Placenta; Fibroblastic Proliferation of the Stroma of the Villi, with Obliteration of Chorionic vessels.

say definitely as to when they acquire a pathological significance, and their relation to syphilis is still more obscure. It is often impossible to say from the microscopical findings in the placenta whether the fetus has syphilis; but there are changes that are pathognostic of placental and fetal syphilis. Fränkel observed in cases of early fetal syphilis transmitted from the father a form of acute interstitial chorionitis in which there is a marked proliferation of the cells of the villous stroma. This loses its myxomatous character, its blood-vessels are obliterated, the villi become greatly thickened, and as a result the intervillous spaces are decreased in size. The newly formed stroma is of a fibroblastic character, rich in large spindle-shaped cells, having more or less vesicular nuclei. (See Fig. 1383.) The change may affect the entire chorion, or scattered areas of the condition may be found throughout the organ. The former is most likely to occur when the infection occurs at conception, the latter in syphilis acquired in the first months. In the former case death of the fetus and abortion invariably result, in the latter gestation may go on to full term with the birth of a child showing marked syphilitic manifestations. The fibroblastic character of the affected villi may be maintained until delivery, or the stroma may gradually assume a hyaline character. Early and marked sclerosis of the chorionic vessels, even of the smallest vessels, accompanies the process, and, as a result of this, infarction occurs to an excessive degree. While

this form of interstitial placentitis is pathognostic of congenital syphilis, it does not, however, occur in all cases of early congenital syphilis, and fetal syphilis may exist without any apparent changes in the placenta. Syphilis of the mother, acquired in the later months of gestation, may or may not affect the chorion. The general effect of maternal syphilis upon the chorion is the production of a premature senility as shown by early and extensive sclerosis and infarction, but none of the chorionic conditions caused by syphilis has anything specific in its character. A similar interstitial chorionitis (localized and not diffuse) may be caused by the tubercle bacillus. Nevertheless, any marked degree of this cellular hyperplasia of the villi occurs only in syphilis. Gummatous growths are not found in the chorion, though they have been described as occurring in the maternal portion of the placenta. The *endometritis placentaris gummosa* of Virchow was most probably a condition of marked infarction, as infarcts are more common in the syphilitic placenta.

In doubtful cases portions of the placenta should be treated by Levaditi's method for spirochetes. Paaschen, Wallich, Levaditi, Mohn, and others have repeatedly demonstrated the *Spirochæta pallida* in the chorionic villi when the fetus was syphilitic, even when the placenta showed no pathognostic changes. According to Mohn the spirochete is found in seventy per cent. of placentas when the parents are syphilitic.

Tuberculosis.—Tuberculosis of the fetal placenta has been repeatedly observed during the last decade (Schmorl, Kockel, Warthin, etc.). Typical caseating tubercles, with giant cells, and containing tubercle bacilli, have been found in the chorionic villi, and the writer has seen one case in which there were localized areas of interstitial chorionitis, with giant cells but without caseation, containing tubercle bacilli. The fetus may be infected secondarily to the tuberculous condition in the chorion, while in other cases, as the one reported by Schmorl and Birch-Hirschfeld, tubercle bacilli may be found in the fetus without the occurrence of changes in the chorion characteristic of tuberculosis. It is doubtful if the bacilli in the blood of the maternal sinuses pass through a perfectly normal syncytium, the tuberculous proliferation of the cells of the villous stroma being either secondary to a necrosis of the syncytium, upon which the bacilli have lodged, or the diseased villus had previously lost its plasmodial covering, whereby the bacilli were brought into direct contact with the stroma. Tubercles of the chorion may appear as intervillous tubercles, intravillous tubercles, or as intravascular chorionic tuberculous thrombi, according to the localization of the tubercle bacilli upon the syncytium in the stroma of the villus, or on the endothelium of a chorionic vessel. In the intervillous and intravascular tubercles the first lesion is a necrosis of the syncytium or endothelium which leads to the formation of an agglutination thrombus that later becomes converted into a tubercle. The literature of placental tuberculosis was collected by Sitzenfrey (1908), but reports of new cases are constantly appearing, the number growing in proportion to the number of placentas from tuberculous mothers that are given careful histological examination. Thus Schlimpert (1910) found either histological lesions or tubercle bacilli in 85.7 per cent. of placentas examined from tuberculous mothers. Other writers have demonstrated the presence of tubercle bacilli in placentas of tuberculous mothers by antiformin digestion of the placenta. Usually the mother has acute miliary tuberculosis, advanced pulmonary tuberculosis or tuberculosis of the genital tract. The writer has, however, recently seen a case of miliary tuberculosis of the placenta coming from a mother who had no evidences of active tuberculosis, but with an apparently healed lesion of the right apex. Placental tuberculosis can no longer be regarded as rare, its occurrence is in proportion to the examinations of placentas from tuberculous mothers. Tuberculosis of the chorionic villi may also occur in ectopic gestation, as in a case reported by the writer in which the cyst wall, placenta, and fetus, as well as both Fallopian tubes, were tuberculous.

Atelectasis of Chorion.—Küstner has observed in the lowest portion of normal placentas, and especially in placenta prævia marginalis, certain areas in the edge of the organ which were thinner, firmer, dryer, more homogeneous, and of a browner color than normal. Microscopically, no other pathological changes are found beyond such a close crowding of the villi that the intervillous spaces are obliterated. He has explained these changes as being the result of a continued pressure from overlying parts of the fetus, and comparing the condition to atelectatic changes in the lungs he has designated the condition as chorionic atelectasis.

Tumors.—The most frequent and important of the new growths of the chorion are those resulting from increased activity in the syncytium. These form a large class of closely allied conditions, ranging from a simple hyperplasia of the villi to atypical growths of a malignant nature. Since all writers are not yet agreed upon the genesis of the syncytium, the terminology of these growths is unsettled and confused. They may, however, be divided into two large classes: the moles or benign syncytiomata, and the syncytioma malignum.

*Moles.*—A simple hyperplasia of the chorionic villi may occur at any time during the progress of gestation, or in the retained chorion after abortion or delivery. This hyperplasia is essentially due to a proliferation of the syncytium, the growth of the stroma being secondary. When the growth is toward the uterine cavity, it may be termed a benign placenta polyp (fleshy mole, placentoma, etc.). If the newly formed villi consist of fibrous connective tissue a fibroid placental polyp is produced which has been called fibroma chorii. The hyperplasia is, however, most frequently associated with a myxomatous degeneration of the stroma of the new villi. This may involve a limited number of villi or the entire chorion (hydatid mole, mola hydatidosa, vesicular mole, grape mole, bladder mole, myxoma chorii, etc.). The myxomatous change begins in the center of the villus, while at the same time there is a peripheral growth of the syncytium and subsyncytial layer. As a result of this coincident proliferation and degeneration the villi come to appear as small cysts or bladders filled with a mucin-containing fluid, which are strung together by delicate pedicles in a manner suggesting bunches of grapes or resembling the variety of seaweed known as bladder wrack. The individual cysts have a diameter of 0.1 millimeter or greater, and are fastened to slender pedicles which arise from other cysts or directly from a chorionic stem, which as a rule shows much less change. The cyst walls are very thin and delicate. The mass of cysts is usually held together by blood clot and covered with a thick layer of decidua. They may weigh five or more pounds. Microscopically the cysts are found to be much-changed villi, the central portion consisting of a cavity filled with a serous or mucin-containing fluid, through which a few strands of stroma remain preserved. The blood-vessels of the stroma entirely disappear. Toward the periphery there is a transition into a more dense myxomatous tissue, while just beneath the syncytium there is a thin layer of stroma of normal type. If the degeneration of the stroma occurs early in the development of the villus, the stroma may become entirely fluid; but if later, fibrous threads remain, giving an appearance more nearly resembling edematous tissue than

myxomatous. According to Marchand, no mucin is found in the cysts, the process being a hydropic rather than a myxomatous degeneration. Other writers affirm the occurrence of a myxomatous change, and cresyl violet and other specific mucin stains in the hands of the writer have shown an increased mucin-formation in the cysts. The chorionic epithelium shows marked changes. Both the syncytium and Langhans' layer show a marked, but irregular hyperplasia, forming cell-heaps of varying size. Many or all of the cells may be vacuolated and swollen, as if hydropic. Glycogen is present in Langhans' cells, and fat-droplets in the syncytium. V. Franque regards the condition as due to a secretory anomaly of the cell-layer of Langhans. Durante holds that the primary cause of the cystic formation is the disappearance of the capillaries of the villi as the result of a progressive proliferation of the endothelium, as endocapillaritis obliterans due to maternal toxins. The well-preserved epithelial covering of the villi removes osmotic substances out of the maternal blood into the stroma of the villus, where it collects, since it cannot be absorbed by the fetal blood-vessels. The over-nourished syncytium proliferates in excess of the distention of the stroma. According to this view the hydatrid mole may be regarded as an adenoma of the chorionic villi. The fetal epithelium may also penetrate into the stroma of the villi, and the proliferation and penetration of the epithelial cell masses into the decidua far exceeds the normal. The normal relations of compact and cavernous layers of the decidua are lost, and the cell masses may penetrate into the uterine wall. The ends of the degenerating villi are either free or fastened to the uterine wall. If these infiltrate the wall, the hydatid mole may take on a malignant character and should then be classed as a malignant syncytioma. The causes of the hyperplasia and degeneration are unknown. It may be assumed that after death of the fetus the excess of nutrition supplied to the chorion leads to increased formative activity on the part of the syncytium, and the degeneration of the stroma may be due to an inability of the latter to keep pace with the former in proliferation. The hydatid mole develops most frequently in three to five months. When it forms during the first two months the entire ovum is transfromed into the mole without signs of fetus (sterile mole). When developing later remains of the fetus may be found. The etiology is obscure. Endometritis, abnormality of the ovum, etc,. are regarded as probable causes; albuminuria, nephritis, and edema are often associated with it. Dangerous hemorrhage may occur. On the whole, the condition is rather rare. Hemorrhages from the decidua frequently accompany the proliferation of the villi, and large masses of fibrin may be formed around the new villi (fibrin mole). Though these chorionic hyperplasias most frequently follow abortion and delivery, they may begin during the course of an apparently normal gestation and lead to abortion. After the death of the fetus the growth may continue indefinitely, and may at any time assume malignant characteristics. They may also arise in the vagina or in the cyst walls of ectopic gestations, wherever chorionic villi may be retained after death of the fetus. Since by some writers the syncytium is regarded as being ectodermal in origin, the various forms of benign moles have been styled benign chorioepitheliomata, since in all cases it is the syncytium which governs the development of the stroma. These growths must then be placed among epithelial tumors, as the process is essentially a syncytial overgrowth; and not among connective-tissue tumors with which they were formerly classed.

*Syncytioma Malignum* (*Chorioepithelioma*).—Since the chief factor in the formation of the hydatid mole is the proliferation of the syncytium, this growth bears a close analogy to an adenoma, and when the syncytial buds and cells infiltrate the maternal tissues, giving rise to metastases, it becomes carcinomatous in nature (malignant chorioepithelioma or syncytioma). The histological structure of the mole does not in itself give evidence of its benign or malignant character. Apparently benign moles may give rise to metastases, while, on the other hand, transported villi may fail to give rise to new growths. The behavior of the transported villi is governed solely by the covering epithelium and its relation to other structures (infiltration). The criterion here of malignancy is the growth of chorionic epithelium through the basal decidua into the veins of the uterine wall, and the destruction of the latter. Perforation of the serous coat, peritonitis, hemorrhage, and metastases

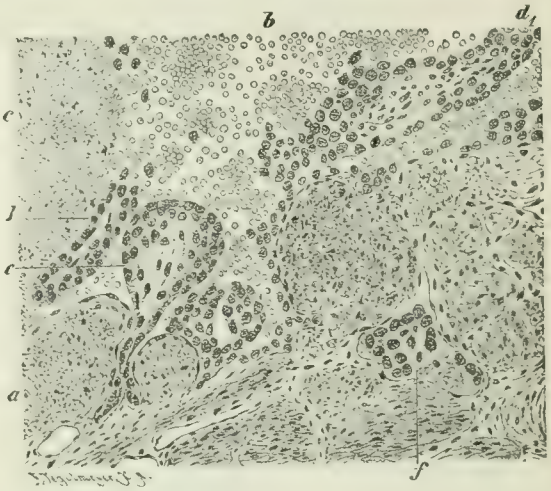



FIG. 1384.—Syncytioma Malignum. Infiltration of muscle of uterine wall by atypical plasmodial masses arising from the chorionic syncytium. (After Ziegler.)

characterize this neoplasm. The cell masses themselves quickly become necrotic. Marchand distinguishes between two forms of chorioepithelioma, typical and atypical. In the former the chorionic epithelium appears as in the early months of gestation, consisting of irregular, branching, intensely staining, often vacuolated plasmodial masses surrounding masses of lighter, polyhedral cells, rich in glycogen. The latter correspond to the type of cell of the Langhans layer of the chorionic ectoderm, while the plasmodial masses represent the syncytial layer. The arrangement of the two types of cell is always the same; the syncytial cells form cords and trabeculæ enclosing the cells of the Langhans type, and are always in contact with the blood or the tissue which the neoplasm is infiltrating. The syncytial masses have a marked destructive action upont he tissues with which they come in contact, and under their action the latter rapidly melt away, leaving cavities filled with blood in which the neoplasm grows. The tumor, therefore, has always a hemorrhagic character. In the atypical form the cells are irregular and compact, with very large and deeply stained nuclei, and while multinuclear cells are present there are no continuous plasmodial masses. The atypical form, when infiltrating, may resemble either sarcoma or carcinoma, but in the secondaries no stroma is formed as in carcinoma. In the atypical form regular cords or trabeculæ of syncytial cells do not occur, and there is not the regular arrangement of the two cell-types. The cells are much more irregular in size and shape, and frequently have giant nuclei and resemble giant cells so that the neoplasm may be confused with a giant-cell sarcoma (sarcoma deciduocellulare). Cells of syncytial type and occasionally of the Langhans type are present.

Intravascular growths of both types may occur, and either lymphogenous or hematogenous metastasis. Secondaries are most frequently found in the vaginal walls and lungs, but occur also in the liver, brain, kidneys, ovaries, spleen, etc. The combination of branching plasmodial masses, the presence of cells corresponding to those in Langhans' layer, the absence of blood-vessels and connective-tissue cells in the intravascular growths are characteristics seen only in growths arising from chorionic epithelium. Neumann regards the presence of syncytial elements in the stroma of the villi as a diagnostic sign of syncytioma, but the writer believes that it is possible to find syncytial elements in the chorionic stroma in every mature placenta, and that no pathological significance can be attached to them.

The weight of authority at the present time accords to the syncytium a fetal and ectodermal origin. The ectodermal nature of Langhans' layer seems to be definitely established, and between it and the syncytium there exist transitional forms which point to a common origin for the two layers. The term chorioepithelioma would then seem to be justified. Both the hyatid mole and the chorioepithelioma arise as a result of the increased formative activity of the chorionic epithelium after the death of the fetus. The normal inhibition being thus removed, the syncytium may continue to grow indefinitely and in an atypical manner. Its cells become loosened and through chemotaxis enter the maternal vessels giving rise to metastases. The necessity of an early removal of all retained placentas is therefore clearly indicated, as malignant changes may occur at any time. There is a very close relationship between the hydatid mole and the malignant syncytioma; in more than half of the cases of the latter neoplasm there has been a hydatid mole present. Bearing this in mind a thorough removal of all hydatid moles is indicated, and the uterus should be thoroughly curetted as soon as the presence of a hydatid mole is discovered. Between the normal placenta, the retained placenta after abortion or delivery, the hydatid mole, and the malignant syncytioma all possible transition-forms exist, as well as between the typical and atypical syncytiomas. The malignant syncytioma is one of the most malignant tumors known and death may take place in a few weeks after its development. It should be borne in mind that hydatid mole and syncytioma may develop in an ectopic sac of the tube or in the vaginal wall. Syncytioma also apparently develops after long periods of latency, as after the menopause, but there is good reason to doubt the syncytial origin of these postmenopause tumors. They are probably carcinoma with plasmodial masses.

*Connective-tissue Tumors.*—The number of reported cases of circumscribed connective-tissue growths of the chorion is very small. In 1897, Niebergall collected from the literature thirty cases of placental tumor, to which in the next year Albert added six more cases. Of these 14 were diagnosed as *myxoma fibrosum*, 10 as *fibroma*, 9 as *angioma*, 2 as *sarcoma*, and 1 as a *hyperplasia* of the villi. Of these the two diagnosed as sarcoma showed no evidences of malignancy, and the one designated as hyperplasia was described as a circumscribed tumor. It is probable that these three belong to the same class as the others, and the similarity of all these growths in structure would make the diagnosis of *angioma fibromyxoma* applicable to all. In 1903 Dienst increased the number of observations to forty-five cases and showed that all were of the nature of a capillary angioma to which he would apply the term *chorioma*. Since then the total number of reported cases of placental tumor is 78, and of these Schindler (1908) regards 40, at least, as angiomatous in structure, with four reported since then, making 44 cases of chorioangioma in all. As the first case of placental angioma was that of Clarke in 1788, the number of reported cases is small. In the case of all these tumors it has been shown that the chorion is the seat of growth, and that neither decidua nor amnion is concerned in their origin; further, that the tumor arises from one cotyledon, even when multiple, having but one artery and vein. No degenerative changes were found in the remaining portion of the chorion that could be in any way associated with the origin of the growth. According to Albert these circumscribed chorionic tumors arise not from the degeneration of an existing cotyledon, but represent an atypical proliferation of a portion of the allantois, which through some unknown error of development has failed of normal growth, and retaining its embryonic impulse to proliferation leads to the formation of an atypical mass which may consist chiefly of myxomatous tissue (myxoma), connective tissue (fibroma), branching vessels (angioma), or of combinations of these. If the resulting formation is very cellular, it may be taken for a sarcoma, but has not the malignant characteristics of this form of growth. No name has as yet been proposed for these growths which will indicate both their origin and nature. The view held by Schindler is the more probable. These tumors arise as the result of a chronic venous stasis of a cotyledon due to some obstruction in that branch of the umbilical vein. This results in a dilatation of the veins and capillaries of the affected villi followed by a hyperplasia of the stroma of the villi. They are therefore, not true neoplasms, but disturbances of placental development due to stasis. Transition-forms between normal villi and angiectatic villi are found about these tumors, and one case has been reported in which the entire chorion showed a "diffuse angiomatosis." Hydramnios is frequently associated with these angioma-like tumors of the chorion; asphyxia is common in the children while the mothers show a high percentage of renal and cardiac disease.

Fig. 1385.—Cyst of Chorion. (After Fenomenow, *Arch. f. Gyn.*, Bd. xv.)

*Cysts.*—Aside from the cases which are very evidently to be classed with the hydatid mole few cysts of the chorion have been reported. These have been large thin-walled cysts filled with a clear fluid, situated on the fetal surface. In a few an epithelium-like lining has been observed. According to Jaquet, four varieties of placental cysts are found: Gelatinous, arising from the space between the chorion and amnion, perivascular cysts, blood cysts, and degeneration cysts of the villi. Hegar and Maier believe that chorionic cysts may arise from the encapsulation and absorption of old hemorrhages. They may also

arise from the simple softening of infarcts or as a sequel of chorionitis. Albeck and Runge believe that the subchorial cysts arise from the degeneration of hyperplastic islands of decidua cells under the chorion. Blau regards them as due to the proliferation and degeneration of fetal cells arising from the trophoblast. Further, cysts may arise from disturbances in the development of chorion and amnion. In the case of the large monolocular chorionic cysts the cause and manner of formation are wholly obscure. Amniotic cysts may also project into the chorion (endochorial cysts).

*Secondary Neoplasms.*—Only one case is reported in the literature of the metastasis of a malignant tumor into the placenta, and that is Walz's observation of multiple placental metastases of a sarcoma of the femur.

Parasites.—The microorganisms found in the maternal circulation will appear in the blood of the maternal sinuses. It is a question whether these are able to pass through a perfectly normal and intact syncytium, but the present opinion is that the chorionic epithelium in a normal state acts as a barrier to the passage of organisms from the maternal blood to that of the fetus. Some lesion of the syncytium, such as necrosis or desquamation, seems to be necessary for the passage, and this injury may be caused by the organisms themselves or be due to other causes. In the human species the bacilli of tuberculosis, anthrax, glanders, typhoid, and cholera, the pus cocci, pneumococcus, malarial plasmodium, recurrens spirillum, spirochete pallida, are known to have passed through the chorion and to have infected the fetus. The virus of smallpox, scarlatina, and syphilis may pass through the placenta, either with or without apparent local changes. Placental hemorrhages are said by Malvoz, Birch-Hirschfeld, and others to force the passage of bacteria. In the case of tuberculosis the bacilli may be found in the fetus when none can be demonstrated in the chorion. The important problems associated with placental transmission of disease have as yet been barely touched upon, and remain a ripe field for future investigations.

Metastasis of Placental Cells.—Schmorl observed in eclampsia the presence of emboli of giant cells in the pulmonary vessels, which he considered to be of syncytial origin. According to his theory these emboli give rise to multiple thrombosis of the pulmonary vessels, which are the direct cause of the eclampsic convulsions. This theory is not accepted at the present time, and eclampsia is now universally regarded as an autointoxication of unknown origin, probably from the placenta. Emboli of placental cells have been observed in cases in which there were no symptoms of eclampsia, in fact, they are present in small numbers in the lungs of all women dying during or just after delivery, although they appear to be more numerous in eclampsia than in any other condition. In the ordinary placental cell metastasis the transported cells probably quickly disappear from the pulmonary vessels, without causing pathological changes. The significance of the increased number in eclampsia is unknown, but there is no reason to believe that they stand in causal relationship to the convulsions. Further, multiple thrombosis of the lungs produced by multiple emboli of liver cells does not give rise to eclampsic symptoms. The whole question of placental-cell embolism is at present somewhat unsettled. Infarction, hemorrhage, fatty degeneration, etc., of the chorion have also been believed to bear a causal relation to the phenomena of eclampsia.

Abortion.—The minute pathology of abortion is for the chief part an unknown field. Fatty degeneration, infarction, hemorrhage, thrombosis, calcification, myxomatous degeneration, etc., have in many cases been supposed to have been the exciting factor of the death and expulsion of the fetus. Just what relation these changes actually bear to the production of abortion it is at present impossible to say. In the majority of cases we are unable to say whether the placental changes are primary or secondary. The association, however, of these changes in the chorion with a relatively large number of cases of abortion makes it possible that when present to an excessive degree they may lead to abortion.

Aldred Scott Warthin.

**Choristoma, Choristoblastoma.**—Defects of development leading to the separation and displacement of tissue and organ anlage may be followed by a hyperplasia of the aberrant anlage in the form of a tumor. To this the term *choristoma* has been applied by Albrecht, Borst, and others to express the close relationship to the true neoplasms. When such a disturbance of development forms the basis of a true autonomous, neoplastic excess of growth, the resulting neoplasm may be classed as a *choristoblastoma*. These terms are convenient in the classification of tumors and tumor-like hyperplasias.

Aldred Scott Warthin.

**Choroid, Diseases of the.**—Anatomical Considerations.—The choroid is of mesoblastic origin; in connection with the ciliary body and iris it forms the vascular tunic of the eye. It originates as a differentiation of mesoblastic formative cells over the outer surface of the secondary eye vesicle; its first appearance being manifested by a plexus of capillaries lying next to the outer surface of the secondary eye vesicle. These capillaries eventually form the choriocapillaris. At first indistinguishable from that portion of the

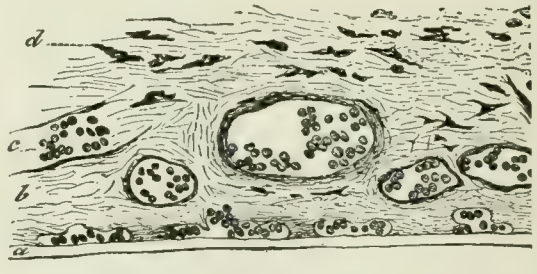



Fig. 1386.—Section of Choroid. (From Quain, after Cadiat.) *a*, Membrane of Bruch—the choriocapillaris is just above it; *b*, vascular layer; *c*, vein with blood corpuscles; *d*, lamina suprachoroidea.

mesoblastic tissue which later becomes sclerotic, it soon becomes differentiated, its principal structure being separated from the sclera by the perichoroidal lymph space. The choroid extends throughout the whole of the posterior part of the globe, its anterior boundary being at the ora serrata. The choroid consists of five layers, which, from without inward, are:

First, *the suprachoroid layer*, consisting of a few nonvascular lamellæ of pigmented fibers which remain attached to the sclera when the choroid is torn from it. Numerous trabeculæ pass from the lamina suprachoroidea to the layer of large vessels traversing the suprachoroidal lymph space.

Second, *the layer of large vessels*, which contains large arterial and venous trunks, numerous nerve fibers, and connective-tissue stroma throughout which are scattered many pigmented branching cells.

Third, *the elastic layer of Sattler*, a thin, rather dense layer composed largely of elastic connective-tissue fibers. It lies between the layer of large vessels and the choriocapillaris.

Fourth, *the choriocapillaris*, a layer of capillaries which anastomose freely, forming a close network. The capillaries are most dense at the yellow spot, the meshes becoming larger as the periphery is approached. The choriocapillaris is continuous through the entire area of the choroid. The capillaries anastomose with those of the optic nerve, but never with those of the retina. The function of this layer is to supply nourishment to the posterior layers of the retina.

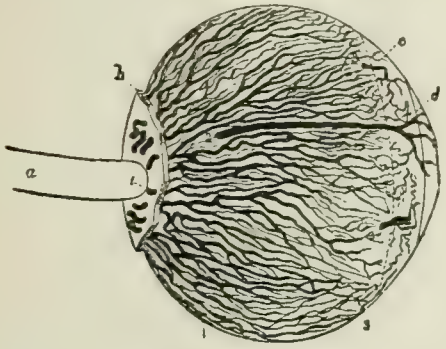



Fig. 1387.—Lateral View of the Arteries of the Choroid and Iris. (From Quain, after Arnold.) *a*, Optic nerve; *b*, part of the sclera left behind; *c*, region of ciliary muscle; *d*, iris; 1, posterior ciliary arteries piercing the sclera and passing along the choroid; 2, one of the long ciliary arteries; 3, anterior ciliary arteries.

Fifth, *the lamina vitrea*, membrane of Bruch, a thin homogeneous membrane separating the pigment layer of the retina from the choriocapillaris.

*Blood Supply.*—The blood supply to the choroid is by the short posterior ciliary arteries, twelve to fifteen in number, which pierce the sclera diagonally about the optic nerve. On reaching the choroid they anastomose rather freely in the layer of large vessels, sending numerous small branches to the choriocapillaris into which the arterial blood flows. About the optic nerve the arteries form a vascular circle, known as the circle of Haller, from which some small branches pass to the retina. Anteriorly they anastomose with the anterior ciliary arteries. The blood is returned

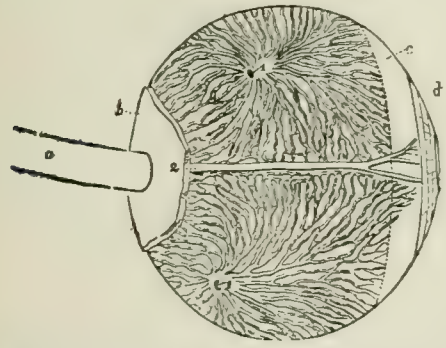



Fig. 1388.—Lateral View of the Veins of the Choroid. (From Quain, after Arnold.) 1, 1, Two trunks of the venæ vorticosæ at the place where they leave the choroid and pierce the sclerotic coat. The other lettering is the same as in Fig. 1387.

from the choriocapillaris by numerous small veins, which pass to larger venous branches in the layer of large vessels. The veins anastomose very freely and finally converge to form from four to six large veins, known as the venæ vorticosæ, which pierce the sclera at the equator of the globe, emptying into the large venous trunks of the orbit.

The amount of pigment present in the pigmented cells of the choroid, as in the pigment layer of the retina, differs largely in different individuals. In the blond it is relatively scanty, in the brunette and negro very dense. In the albino the pigment is wanting and, by means of the ophthalmoscope, the larger veins and arteries of the choroid can be distinctly seen.

Fig. 1389.—Coloboma of the Choroid. (Haab.)

Congenital Anomalies.—*Coloboma of the choroid* is a defect which is usually situated in the lower part of that membrane. It is primarily due to imperfect closure of the retinal fissure in the development of the eye and the consequent imperfect formation of the choroid over the secondary eye vesicle. The retinal fissure, which begins to close at its posterior extremity,

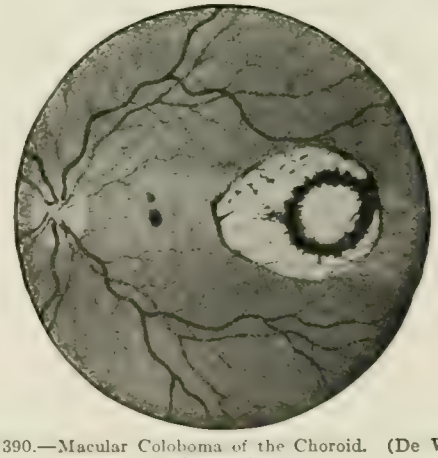


Fig. 1390.—Macular Coloboma of the Choroid. (De Wecker and Masselon.)

should be completely closed by the end of the second month of fetal life; it may be arrested at any stage of development; hence the various differences in shape seen in coloboma of the choroid. The defect is usually separated from the optic disc by a bridge

of normal choroid; it broadens out and extends toward the ciliary body. The border of the defect is irregularly pigmented. The anterior layers of the retina pass over the defect, but all perceptive elements are wanting. Viewed with the ophthalmoscope the defect presents a pearly-white appearance traversed by a few retinal vessels. Coloboma of the iris not infrequently accompanies coloboma of the choroid, and coloboma of the lens is sometimes observed. Bulging of the sclera at the site of the coloboma is sometimes present; this may assume the character of a cyst. The globe in these cases is frequently microphthalmic. Imperfect development of the central nervous system and of the cranium is sometimes observed in these cases.

*Extrapapillary colobomata* are sometimes seen. These are irregularly circular in shape and are generally located in the macular region. So often is this the case that they are termed macular colobomata. Various theories have been advanced to explain the origin of these defects, but none of them has been substantiated.

*Angiocavernomata* are sometimes observed as congenital defects in the choroid. They may occur in any part of the membrane.

Hyperemia of the Choroid.—This condition is undoubtedly present much more frequently than it is recognized. Hyperemia of the choroid is present under the following conditions: In congestion of the head; as the first evidence of a general or localized inflammation of this part of the eye; as an accompaniment of an exudative retinitis; and as a symptom of either leucocythemia or pernicious anemia. A deepening in the color of the fundus and slight reddening of the optic disc accompany this condition; however, unless one eye alone is affected, the change in the appearance of the fundus is so slight that it is impossible to diagnose it by means of the ophthalmoscope. It is held by some writers that hyperemia of the choroid is accompanied by certain subjective symptoms, such as meteoric flashes of light, wavy effects like those produced by the atmosphere when radiated from a heated surface, and at times photopsia. These phenomena are due to disturbance of the perceptive elements of the retina, and, as they often precede destructive processes, they should be given careful attention.

Choroiditis.—The term choroiditis is not sufficiently comprehensive to include all of the pathological processes which affect the choroid, since not all of the processes are inflammatory. It is therefore logical to divide the affections of the choroid into inflammatory and non-inflammatory; to the first the term choroiditis properly applies, to the second the term choroidal atrophy applies. All forms of choroiditis are exudative; for convenience they may be divided into non-suppurative and suppurative. The non-suppurative forms include the seroplastic, plastic, disseminate, diffuse, areolar, circumscribed, hemorrhagic, sclerochoroiditis anterior, and some forms of central choroiditis.

*Causes.*—The causes of choroiditis are the same in all except the embolic or metastatic, the purulent, tuberculous, traumatic, and atrophic forms, and may be considered before descriptions of the various forms are given. The most frequent cause is syphilis, either inherited or acquired. That due to inherited syphilis (which is by far the most frequent cause) is often discovered only after the clearing up of an interstitial keratitis. It is probable that in some cases the choroidal disease precedes the corneal, but no doubt the reverse is true also in many cases. The choroiditis of acquired syphilis may follow the initial lesion in a few months, but it is rare at so early a period; it may occur years later. In all but the serofibrinous and retinochoroidal forms the choroidal lesion due to syphilis is circular in shape, and in some forms of disseminate choroiditis the arrangement of the spots suggests the papillary syphilide as observed on the skin. Rheumatism and gout may account for some of the cases of choroiditis for which syphilis, as a cause, cannot be traced. The history is apparently sufficient in some cases to warrant this supposition, and the treatment by the salicylates is sufficiently productive of results to sustain the opinion. Leprosy is, according to Knies, a cause of iridochoroiditis in rare cases. Gonorrhea in a very few cases is undoubtedly the cause. The form produced is the serofibrinous variety, with involvement of the whole uveal tract. Relapsing fever is sometimes accompanied by a diffuse, seroplastic anterior choroiditis; typhoid fever is also sometimes a cause of this form of choroiditis.

Seroplastic Choroiditis.—This disease is characterized by a relatively sudden onset and the appearance of a serofibrinous exudation in the vitreous. The same exudation is present in the posterior and anterior chambers in many cases. There are more or less congestion of the deep vessels of the ocular conjunctiva and diminution of vision.

*Symptoms.*—Unless the ciliary body or iris is involved no pain is experienced in the cases which do not result in increase of tension. Acute glaucoma may supervene. If this occurs the pain becomes intense. The vitreous becomes filled with minute particles of fibrin which obscure the view of the fundus, and the aqueous may be invaded by the particles which often become attached to the posterior surface of the cornea in the form of a pyramid. The vision is correspondingly obscure. Photopsia is not a prominent symptom. The anterior chamber is shallow because of an increase in the contents of the vitreous chamber. The pupil is moderately dilated.

*Course.*—The disease runs its course in from six weeks to as many months. The opacities in the aqueous humor gradually disappear. Those in the vitreous may entirely disappear, but in many cases some large shreds of exudation remain and are movable in the vitreous, indicating a partial fluidity of that body. No evidence of changes in the choroid is discernible in some cases; in others some atrophic patches at the periphery may be seen after the acute stage has passed. In some cases vision returns to the degree of acuity present before the inflammation began, in others there is a permanent partial loss. If atropine is not instilled, adhesion between iris and anterior lens capsule may occur and the synechiæ become permanent. Recurrence is not uncommon.

*Pathology.*—In this form of choroiditis pericorneal injection is sometines found; the choroidal vessels are engorged with blood. The choroid is slightly edematous. The exudation contains some fibrin. When the acute stage has passed there may be little change in the choroid, but in not a few cases slight atrophic changes occur, affecting the choriocapillaris principally.

*Treatment.*—Quite vigorous antisyphilitic treatment is indicated in all cases which are not clearly attributable to some other disease of the system, but particularly in the cases in which the Wassermann reaction is positive. If there is reason to believe that a rheumatic element is present, the salicylates and the bicarbonate of sodium may be employed. It is not wise to omit antisyphilitic treatment even if no history of syphilis can be elicited. The effect of potassium and mercury to prevent plastic formations is valuable in the non-syphilitic as well as in the syphilitic cases. Iron tonics are also of value in all cases in which hemoglobin percentage is below normal. If the tension of the eye is not increased, it is necessary to apply atropine locally. The solution of this drug should be instilled sufficiently often to prevent the formation of posterior synechia. It is better to have the patient remain in bed until the acute stage of the disease has subsided. Leeches and cold or hot applications are of doubtful value.

Chorioretinitis Syphilitica.—Since in all forms of choroiditis the retina is more or less implicated, it would be more exact to include the retina in all of the terms used to indicate the different forms of choroiditis; but as the involvement of the retina is not a striking part of the picture portrayed by the disease in many of the forms of choroiditis, that membrane is not mentioned. Some of the forms involve the retina very seriously, and to one of these the term chorioretinitis syphilitica is given; to another, the

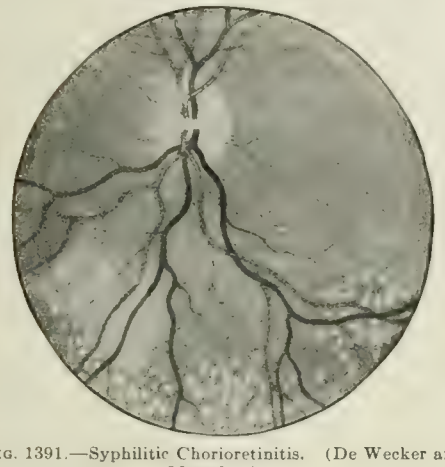


Fig. 1391.—Syphilitic Chorioretinitis. (De Wecker and Masselon.)

term chorioretinitis pigmentosa is applied. Chorioretinitis syphilitica is a disease closely allied to seroplastic choroiditis, although it produces more permanent damage to both membranes than does the latter.

The diffuse haziness of the vitreous is present usually to a moderate extent, shreds of exudation appear in the vitreous, and isolated large or small spots of exudation occur in the choroid. The retina appears hazy because of edema, and retinal hemorrhages may occur. The evidence of perivasculitis of the retinal and choroidal vessels is unmistakable. The vision is greatly diminished, and flashes of light, photopsia, micropsia, and macropsia may be experienced. Slight injection of the ocular conjunctiva may occur in the acute stage. Pain is not present. In many of these cases the diagnosis can be made at any stage of the disease, as the vitreous remains sufficiently transparent to permit of a more or less satisfactory examination of the fundus. The exudation into the choroid and retina is serous and plastic. The plastic exudation, which takes place in the form of circular patches, undergoes the same changes as those which characterize the exudation of disseminate choroiditis; atrophy being the terminal stage in both cases. As a result of plastic exudation in the retina, cicatricial bands may develop in that membrane, and they may also develop in the vitreous, in the plastic exudation that sometimes extends into that part of the eye. Detachment of the retina as a result of the traction of cicatricial bands in the vitreous is rare, owing to the fact that the choroid and retina are adherent in many places; but detachment of the choroid and retina together is sometimes seen following degenerative changes in the vitreous. A cataractous condition of the lens and atrophy of the globe are rare results.

The inflammatory stage usually responds quite readily to treatment, but the treatment must be vigorous and long continued.

Diffuse Choroiditis.—This form of choroiditis is characterized by the appearance, in the choroid, of large pale plaques of exudation which are found to be most extensive at the periphery. These patches at first are of quite a uniform orange or pale yellowish-pink color, not bordered by pigment. The retina over the areas of exudation is slightly edematous. The patches coalesce, forming irregular areas with indentations of normal tissue. The forms assumed have been likened to continents and islands and have been termed "map-like." Sometimes they assume the shape of leaves, which has caused them to be termed "leaf-like."

The disease is extremely slow in its development. The exudate slowly appears and as slowly disappears, leaving irregular scanty pigmentation over the affected areas and in some places a little pigmentation at their borders. The pigment layer of the retina and the superficial layer of the choroid, the choriocapillaris particularly, undergo atrophy and disappear. The deeper layers of the choroid remain nearly if not quite intact. There may also be found evidences of perivasculitis and occasionally of almost complete conversion of the larger vessels of the choroid into connective-tissue bands. By ophthalmoscopic examination the larger choroidal vessels and the deep choroidal stroma can be readily seen. The retinal vessels in severe cases become reduced in size, and the optic disc presents hazy edges and becomes slightly pale, giving evidence of partial secondary atrophy of the optic nerve.

Individuals thus affected almost always present the stigmata of inherited syphilis.

*Symptoms.*—The patient experiences no pain nor is there any injection of the external ocular tissues. Night blindness is sometimes experienced, and there is limitation of the visual fields in the parts corresponding to the affected areas of the choroid.

*Prognosis.*—The prognosis for recovery of vision is not good, but much can be done to prevent the further advance of the disease. Treatment is similar to that of disseminate choroiditis.

Disseminate Choroiditis.—This form consists in the development of foci of exudation which are spread out over a large part, often the entire fundus, in the shape of circular patches which vary in size, but as a

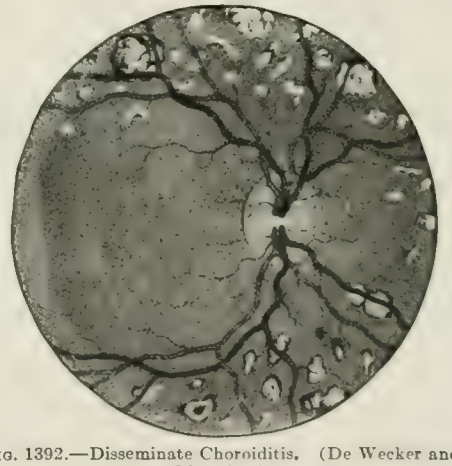


Fig. 1392.—Disseminate Choroiditis. (De Wecker and Masselon.)

rule average in diameter less than that of the optic disc. After a time the exudation becomes absorbed or changed into fixed products, and atrophic areas occupy the site of the areas of exudation. The disease may for convenience be divided into two stages—the acute stage and the stage of atrophy.

*Acute Stage.*—In the early part of the acute stage circular spots of exudation appear in certain parts of the fundus, usually beginning at the periphery; they are paler than the surrounding normal fundus. These

spots have not very sharply defined borders. The retina immediately over the masses of exudation is not elevated, as may readily be determined by examination with the ophthalmoscope, but there is often an invasion of the retina by the exudate, as evidenced by the hazy appearance of the retina at these points. The spots multiply in number if not interfered with, resembling in many cases the groupings of papillary syphilides as they appear on the skin. The areas of exudation are primarily discrete, but may eventually coalesce. The greater part of the fundus may become studded over with these spots of exudation in the course of two or three weeks, but in not a few cases some of the spots will be found to have passed to the second stage when others have but just appeared.

Ordinarily the cornea and media remain clear, but in some cases a parenchymatous keratitis may occur at the time of the onset of the choroiditis, and the presence of the affection of the choroid may not be discovered until the cornea again becomes clear.

*Stage of Atrophy.*—The first stage passes slowly into the second stage. Gradually the exudation disappears, the spot becomes paler, and the border of the affected area ordinarily becomes irregularly pigmented, the pigment being heaped up at certain points. Flecks of pigment are often observed over the area of the spot itself. Entire absence of pigment is not infrequently observed. The exudate either entirely disappears or a portion is converted into cicatricial tissue. All degrees of change may occur in all the layers of the choroid, from slight impairment to complete atrophy, with a disappearance of all vessels and the presence of cicatricial tissue, which, lying over the exposed sclera, presents a whitish patch, tinged slightly with yellow, in the fundus. The pigment changes noted are due to destruction and more or less complete disappearance of the retinal and choroidal pigment of the part affected. The peculiar arrangement of pigment at the border of the spot is due to deposits of retinal pigment which in some cases is apparently increased in quantity. In many cases not interfered with by treatment, the affected parts coalesce and form large areas; it is also known that atrophic spots may enlarge and affect increased areas without the appearance of fresh exudation, probably because of the interference with the nutrition of adjacent tissues.

*Symptoms.*—These are common to all forms of choroiditis—namely, loss of vision in portions of the fields of vision corresponding to the affected areas, and diminution of vision in contiguous parts from impairment of nutrition. Photopsia is manifested variously during the acute stage; there is slight photophobia in the acute stage in some cases.

*Duration.*—The acute stage, if not interfered with, may last for a period of years; as a rule the exudation disappears in from six months to two years, and the stage of atrophy takes possession until the end. Fresh outbreaks of exudation may occur. A choroid that has remained quiet for years may present recent foci of exudation.

*Results.*—More or less atrophy follows the disappearance of the exudation, the atrophy affecting not only the choroid but also the posterior layers of the retina. Destruction of the choriocapillaris probably always occurs at the point of exudation. With destruction of this layer the posterior layers of the retina, including the perceptive layer, are deprived of adequate nutrition and degenerate, and cicatricial tissue is found not only in the choroid but often involving the deep layers of the retina. Impairment of the retina, if extensive, results in atrophy of many of the afferent nerve axis cylinders and consequent subsequent partial atrophy of the optic nerve. The portions of the retina that are sufficiently nourished will preserve the axis cylinders which go from them. Following the impairment of nutrition degenerative changes in the vitreous and in the crystalline lens take place, these changes corresponding in degree to the impairment of the nutrition.

*Treatment.*—Much can be accomplished by vigorous judicious treatment in the acute stage of disseminate choroiditis, but nothing of importance can be done to correct the condition when the atrophic stage has been reached. The treatment is almost wholly constitutional. The exudation is due to localized perivascu-litis, usually of syphilitic origin, and must be treated as such. Mercury and potassium are the remedies on which most reliance can be placed. Iron should also be given. Nourishing diet must be insisted upon. Rest in bed is valuable in the early part of the acute stage. The use of colored glasses and the prohibition of the use of the eyes for close work should be enjoined in the cases due to syphilis. In the acute stage mercury by inunction, by the stomach, or hypodermically, should be given to saturation and potassium iodide until the physiological effects are obtained. These remedies should be continued, a little short of saturation, until the exudation has very nearly or quite disappeared. The treatment in a less vigorous manner should be continued for six months to two years, according to the exigencies of the case, or salvarsan or neosalvarsan may be administered intravenously, two to five doses being given, and this treatment supplemented by treatment with mercury and potassium iodide.

Choroiditis Areolaris (Foerster).—This form is probably a variety of choroiditis disseminata. It usually begins at or near the posterior pole of the eye and first presents itself as a plaque of pigment. Soon the center of the plaque thins and presents a lighter color. The light center enlarges and we eventually have an atrophic patch surrounded by a relatively broad border of pigment. These patches

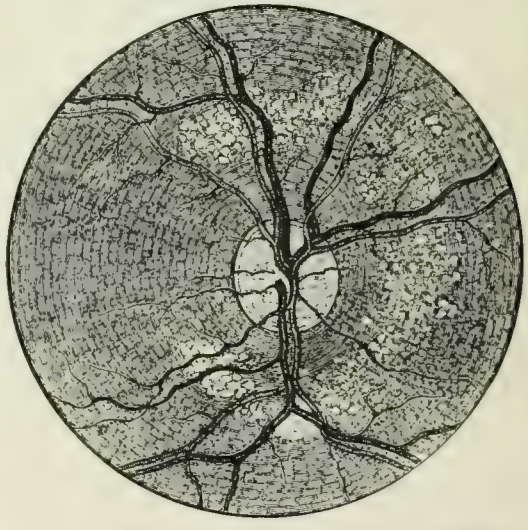


Fig. 1393.—Guttate Choroiditis. (De Wecker and Masselon.)

coalesce and form rather large, irregular patches situated at or near the posterior pole of the globe; exceptionally they are found at the periphery. There are seldom more than two or three patches.

This form of choroiditis is met with in young children, and is thought to be congenital in some cases. It develops also at all ages. There may be few or many patches. The vision may remain very good for a number of years. It may fail quite suddenly without apparent cause.

*Treatment.*—The same as in disseminate choroiditis.

Guttate Choroiditis (Hutchinson and Tay).—The region of the macula is occupied by a number of

small, whitish or yellowish dots which resemble the deposits that occur in the deep layer of the retina in albuminuric retinitis, but are more yellow and are circular or oval. They seldom reach more than one-fourth the diameter of the disc and are often very minute. These spots may be very numerous. They do not tend to disappear; on the contrary, they continually increase, but produce no impairment of vision. This condition is due to the formation of excrescences on the lamina vitrea which project into the retina. They are peculiar to advanced life. These spots are often observed scattered more or less densely over the entire fundus.

*Treatment* is of no avail.

Embolic Choroiditis; Metastatic, Plastic, and Suppurative Choroiditis.—Embolism of one or more choroidal vessels probably occurs more frequently than is recognized. The dozen or more

Fig. 1394.—Excrescences on the Lamina Vitrea, in Guttate Choroiditis. (De Wecker and Landolt.)

small arteries that pierce the sclera anastomose freely when they reach the choroid; consequently the plugging of one artery can make but little difference with the circulation in this membrane. If the plug that enters a short ciliary artery does not contain pathogenic germs the disturbance occasioned is slight. Knapp (*Arch. f. Oph.*, xiv., 1) described two cases of simple embolism in which the onset of the symptoms was quite sudden. The patient noticed a blurring of vision which at first included the whole field, but later became confined to the central portion. In one case the vision equalled one-tenth, in the other case the patient could read the finest print; the patient noticed a large scotoma lying near the axis of vision. There were marked chromatopsia and photopsia. On ophthalmoscopic examination a circumscribed cloud or veil was observed in the central portion of the fundus corresponding to the scotoma, which involved the retina and had extended to the disc. The condition was evidently due to embolism of some of the choroidal vessels at this point, the effusion and hyperemia following as a result. In each case vision was completely restored. Each patient had well-marked cardiac disease. Not infrequently, from a suppurative process taking place in some distant part of the body, a minute mass of pyogenic or pathogenic microorganisms enters the circulation and is conveyed to the choroid on one or both sides; there will then be set up a plastic or suppurative choroiditis. Ulcerative processes located in the alimentary canal or in the genital tract, or affecting the cutaneous surface or any other part of the body, may be the foci from which microorganisms proceed by way of the blood to the choroid; when this takes place the processes just alluded to are established. Direct extension from the meninges of the brain to the eye is said to occur (Wells, American edition, p. 542). Metastasis may occur in cerebrospinal meningitis, puerperal fever, pyemia, smallpox, pneumonia, erysipelas, cholera, and malignant pustule. It has been met with in ulceration of the umbilical cord in the new-born. Plastic choroiditis and tuberculous choroiditis are seldom due to injury, but suppurative choroiditis is frequently the result of perforating wounds of the eyeball as well as of metastasis.

Plastic Choroiditis.—The onset of this disease (due to metastasis or to injury) is similar to that of purulent choroiditis, but is not quite so severe. The vitreous becomes hazy; the anterior chamber usually shallow, but sometimes deepened; the ocular conjunctiva hyperemic. The iris is bound down to the anterior capsule of the crystalline lens. During the first stage there is pain, which is of a dull, continuous character. The vision at any early stage is soon reduced to perception of light only and may fail entirely. Soon a yellowish reflex is observable from behind the pupil, due to the presence of plastic lymph in the vitreous chamber. The plastic lymph may fill the whole vitreous chamber or it may be spread in a layer of varying thickness over the fundus. The globe is usually soft, but in the early stage it may have a slightly increased tension. In the average case of this form of choroiditis the globe, which at first appears to be slightly distended, gradually shrinks, becoming smaller than its fellow; it maintains this shrunken condition, the vision being entirely lost. In the very mild cases some degree of vision may be retained.

*Diagnosis.*—In the severe cases the inflammatory reaction is so marked and the progress of the case to atrophy of the globe is so unmistakable that the diagnosis is readily made; but in the milder cases the color of the reflex, the degree of tension, and the size of the globe, the presence of blood-vessels, and the situation of the exudate are such that it is very difficult to separate these cases from those of glioma and other intraocular tumors. In making a differential diagnosis the history of the case in every particular must be obtained, as this is the most important factor. A history of meningitis or of some one of the eruptive fevers, or of a suppurative process just preceding or occurring at the time of the onset of the eye disease, aids much to clear up the diagnosis. Adhesions between the iris and lens with a broadening of the sinus of the anterior chamber, atrophy of the iris, minus tension, reduction in the size of the globe occur in metastatic plastic choroiditis, but they are seldom met with in glioma. There may be tenderness on pressure, but this may also be present in glioma.

*Treatment.*—In the mild cases the use of mercury and iodide of potassium seems to exert a beneficial effect by preventing plastic formations; some degree of vision may be retained in these cases. In all cases in which vision is *nil* and the question of glioma cannot be settled, or in which the globe is at all painful, enucleation may be resorted to. Recurrent inflammation may also render enucleation advisable.

Suppurative Choroiditis (Panophthalmitis).—Suppurative processes originating in the choroid are not confined to this membrane but involve all the tissues of the interior of the eye, often perforating the sclera or cornea. The general nature of the affection entitles it to the term panophthalmitis.

*Cause.*—The cause is most commonly an injury, accompanied by the introduction of pyogenic or pathogenic germs. Metastasis may be the manner of infection, pus-producing microorganisms being carried to the choroid from purulent processes occurring in distant parts of the system. The germ most often found is the staphylococcus, but the streptococcus and the pneumococcus have been found as causative factors.

*Symptoms.*—Severe continuous pain is experienced almost from the beginning. The sight is lost very early. After the infectious material has effected a lodgment a period of from twenty-four to forty-eight hours elapses before the disease obtains sufficient headway to occasion great discomfort. Then the ocular conjunctiva becomes swollen and hyperemic. Chemosis, sometimes to an enormous degree, causing

the conjunctiva to protrude between the lids, exists. The lids are frequently enormously swollen. The tissues of the orbit also partake of this condition, causing the eyeball to bulge forward. The flow of tears is increased and some mucopurulent discharge from the conjunctiva is often observed. The anterior chamber becomes shallow and the aqueous humor turbid. A yellow reflex is often seen through the pupil. The tension is often much raised, although in some cases it is reduced. The cornea becomes gray and in many cases sloughs, permitting the escape of pus from the interior of the eye through the opening thus formed. The pain is not confined to the eyeball, but is experienced in the side of the head corresponding with the affected eye. After some days the inflammation subsides, pain diminishes, and at the end of three or four weeks the acute stage of the process terminates. The globe gradually shrinks and passes into the condition known as phthisis bulbi.

*Treatment.*—Hot applications by means of hot water or poultices, with the administration of laxatives, is often resorted to; but the more modern treatment is to regard panophthalmitis as an abscess or phlegmon of the eyeball and to treat it as abscess or phlegmon is treated when it occurs in other parts of the body. In the early stage before the globe has ruptured and before there is much swelling of surrounding tissues enucleation may be resorted to. A crucial incision through the cornea, followed by frequent cleansing of the eye with an antiseptic solution (bichloride 1 to 5,000) and by hot poulticing, does much to shorten the process and to relieve pain. Complete evacuation of the contents of the globe (evisceration) is much better treatment in the early stage of the affection. This is accomplished by excising the cornea, removing the entire contents of the sclera by means of a suitable curette, cleansing the cavity thus formed with bichloride (1 to 2,000), packing with aseptic gauze, and bandaging. The bandage and packing are changed as often as required. This treatment, which has never resulted fatally to the patient, stops the process together with all its attendant discomforts and pain at once, and converts a pus-forming process into a surgical wound. Recovery is rapid. The cavity becomes filled with granulation tissue. Packing the cavity is to be discontinued as healing advances, and eventually the sclera and its contained granulation tissue shrink and form a small irregularly spherical mass, which is not sensitive and over which an artificial eye can be worn.

Tuberculosis of the Choroid.—This is usually due to the formation of miliary tubercles in the stroma of the choroid. It is metastatic in origin and commonly accompanies tuberculous processes in other parts of the body. The disease appears most frequently in children and is more common in individuals who suffer from tuberculous meningitis. Michel (*Augenheilk.*, p. 404) puts the percentage of cases of tuberculosis of the choroid accompanying tuberculous meningitis in children at thirty-five to forty. Large conglomerate tuberculous masses may develop in the choroid; they may be single or multiple. As a rule they are accompanied by a white spongy exudation which may extend into the vitreous body. One eye only is involved as a rule but both may be affected.

*Symptoms and Diagnosis.*—The patient complains of no pain. The condition is diagnosed by use of the ophthalmoscope. The tubercles usually appear at the posterior part of the fundus, and are not visible until they occasion disturbance of the retinal pigment layer. At first, there is observed a small spot of pigment slightly more pronounced than the surrounding fundus; this is due to slight prominence of the pigment layer over the tubercle. Soon the center of the pigment patch takes on a pale whitish color, circular or oval in shape, due to absorption of the retinal pigment, and this reaches the size of the optic disc—sometimes a little smaller, sometimes larger. If a number of miliary tubercles are grouped together, as is often the case, the size and shape of the patch are changed. Many tubercles may be scattered over the fundus, or there may be but one or two tubercles present. Retinal vessels pass over the patch, the retina is slightly raised, and in some cases a slight local detachment of the retina occurs. Vision is but little interfered with, except in the portion of the field corresponding with the site of the tubercle, where there is a relative or complete scotoma.

*Treatment.*—In miliary tubercle and in small conglomerate tubercle of the choroid, if the system is not greatly involved, much can be accomplished by the use of tuberculin. In many cases the disease may be arrested. If the system is greatly involved nothing need be done for the relief of the eye, as the disease which occasions the metastasis usually proves fatal. In large tubercle of the choroid enucleation should be resorted to for the purpose of relieving symptoms due to the local process and to prevent the spread of the tuberculosis.

Leprosy of the Choroid.—The choroid is sometimes invaded by the bacillus of leprosy as an extension from the ciliary body; the disturbance occasioned is slight.

Hemorrhagic Choroiditis.—The vessels of the choroid, like those in other parts of the body, are from time to time the seat of disease, and their walls may become so weakened that the fluid and at times the corpuscular portions of the blood may escape into the tissue of the choroid and also beneath the retina. The escaped blood may break through the retina and enter the vitreous. The appearance presented is that of large, irregular patches of blood clot which often cause the retina to bulge forward. Through the action of gravity the upper border assumes a horizontal line, the lower border being curved. Above the clot the tissues are tinged a yellowish red by the partly absorbed blood pigment. The clot gradually becomes absorbed, leaving a white patch of atrophy with some pigment scattered over it. Choroidal hemorrhage may produce acute glaucoma.

*Treatment.*—The treatment is restricted to the care of the general condition of the vascular system.

Detachment of the Choroid.—This is rarely met with, but it sometimes follows an exudative inflammatory process in which the exudation, serous or fibrinous and large in amount, finds its way between the choroid and the sclera. It may be due to the presence of a tumor or to hemorrhage, and it may accompany a degeneration of the vitreous during the course of an irido-cyclo-choroiditis.

Non-inflammatory Affections of the Choroid.—The *atrophy accompanying myopia* is rarely inflammatory. The axial elongation of the globe in myopia is due to the thinning of the posterior segment of the sclera, and, as shown by the ophthalmoscope and by postmortem section, the greatest stretching of the sclera takes place at or near the optic disc. The change in the tissue of the sclera is not accompanied by any infiltration of small cells (the characteristic accompaniment of inflammatory processes), nor do we find such infiltration of small cells in the issue of the choroid. The small myopic crescent is not a condition due to pathological changes in the choroid, but, as Michel has shown, the bulging of the sclera causes the optic disc to become more obliquely placed to the anteroposterior axis of the globe than is the case in the normal eye, and the transparent tissue of the optic papilla permits the white, opaque tissue of the edge of the sclera and the optic nerve sheath (usually at the inner lower quadrant of the disc) to show through. The nasal side of the disc is sharply defined, but the lower temporal side is ill-defined. (Fig. 1395.) In high degrees of myopia the choroid at the posterior pole of

the eye suffers most; at the periphery the membrane is but little changed. The condition met with is one in which the choroid is thinner than normal. The meshes between the capillaries of the choriocapillaris and between the vessels in the layer of large vessels are enlarged. The choroidal pigment is more spread out and the retinal pigment is also rendered much less dense. In eyes thus affected the white sclera shines

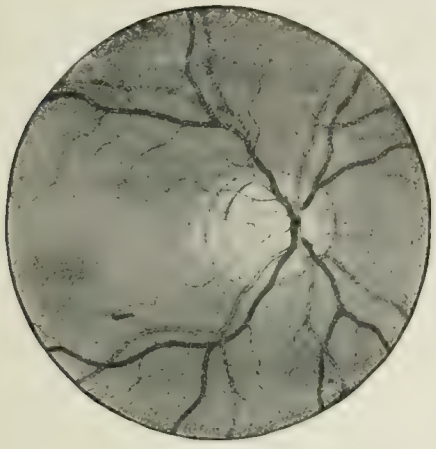


Fig. 1395.—Sclerochoroiditis Posterior of Moderate Degree. (De Wecker and Masselon.)

through to a greater extent, giving the fundus a pale appearance, often referred to as *rarefaction* of the choroid. The stretching of the vascular tunic may be so great that small choroidal hemorrhages appear at or near the macula, and, because of atrophy of the choroid at this point, a condition sometimes known as central choroiditis is produced.

*Superficial Senile Choroiditis.*—This condition is due to atrophy of the choriocapillaris; it is often accompanied by disappearance of retinal pigment over the affected area and at the same time a deep atrophy of the choroid corresponding to an obliterating arteritis of some of the larger arterial branches.

Fig. 1396.—Chorioretinitis Pigmentosa. (De Wecker and Masselon.)

*Chorioretinitis Pigmentosa.*—This is an example of a non-inflammatory process. A non-inflammatory degeneration takes place, affecting the vessels of both membranes and also affecting the structure of both membranes. This atrophy proceeds from the periphery toward the posterior pole. In some cases the vascular degeneration is accompanied by an escape of portions of the blood, which may, on becoming absorbed, leave atrophic spots in the choroid, or rather spots in the choroid from which all pigment has disappeared. Ordinarily, in cases of general atrophy of the choroid, the choroidal pigment is changed but little. A change in the retinal pigment is often noticed, sometimes amounting to an hyperplasia of the pigment, as is the case when the bone-corpuscle figures are seen. Sometimes the change is of such a character that the retinal pigment is heaped up, as in cases in which a deeply pigmented margin occurs about an atrophic choroidal patch. The ganglion cells of the retina and the axis cylinders perish as the disease advances, and secondary atrophy of the optic nerve follows as a consequence.

It sometimes happens that this passive atrophy begins at the posterior pole of the choroid, and there is then produced that variety of the condition to which the name *chorioretinitis centralis* has been given. In this type of the affection the vision fails as the disease advances. If the periphery is first attacked the field of vision is narrowed concentrically; if the process first appears at the posterior pole, a relative, negative, or positive central scotoma follows. The affection under discussion is termed chorioretinitis pigmentosa or retinitis pigmentosa, according to the degree of visible involvement of the choroid. If some atrophic choroidal patches are seen the affection is termed chorioretinitis pigmentosa; if no such patches are present, the affection is supposed to involve the retina principally and is termed retinitis pigmentosa. In reality these processes are one and the same so far as their pathology is concerned. On examination with the microscope both membranes are found to be in a condition of atrophy.

Chorioretinitis pigmentosa is often congenital in origin and is sometimes accompanied by degenerative processes in other tissues of the body. It is influenced by heredity. Consanguinity in the parents is supposed to be causative in about thirty per cent. of the cases. Inherited syphilis is thought to be a cause.

The obscure affection known as retinitis proliferans is also a disease in which atrophy of the choroid is an accompanying condition.

Traumatism of the Choroid.—This may affect the membrane in a number of ways. Hemorrhage and rupture of the choroid are frequently met with

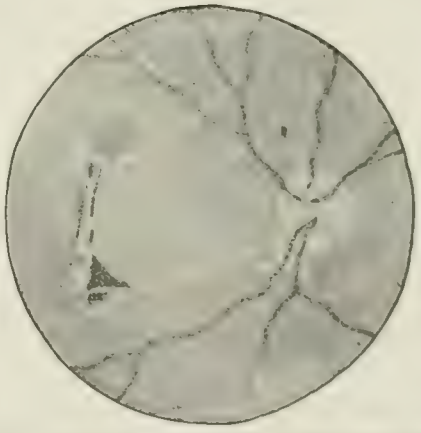


Fig. 1397.—Rupture of Choroid. (De Wecker and Masselon.)

as a result of a non-perforating blow on the eye, the lesion usually appearing at a spot opposite to the point of impaction; the rupture being due to contrecoup. Hemorrhage may be from the capillaries, which is most frequently the case, or from large vessels. In rupture of the choroid the injured portion is obscured by the hemorrhage and by exudation which usually goes on for a few hours (Fig. 1397). The exudation passes into the retina and extends into the

vitreous. When the exudation and blood have become absorbed, a crescentic atrophic patch is usually seen in the posterior part of the fundus, concentric to the optic disc. The retinal vessels pass over this patch, showing clearly that it affects a tissue beneath the retina (Fig. 1398). Although usually arranged in a manner concentric to the disc, ruptures of the choroid may assume almost any shape. The ruptures may be single or multiple. A scotoma is present in the visual field corresponding with the location of the rupture.

*Wounds of the Choroid.*—These are of all kinds and of all degrees: perforating, lacerating, incised, clean, infected. Perforating wounds of the choroid always involve other membranes, and consideration of these must necessarily involve consideration of other parts

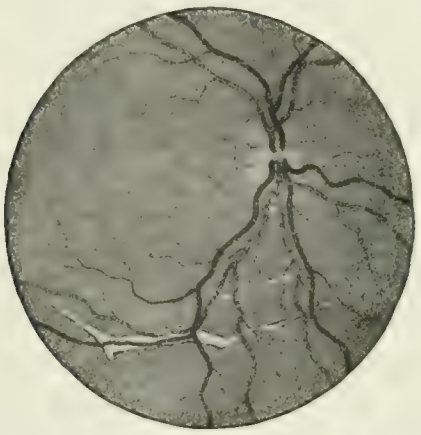


Fig. 1398.—Rupture of Choroid. (De Wecker and Masselon.)

of the eye. Clean, incised wounds, if not too extensive, will heal without destruction of the eye. If the blood clot extends into the vitreous, we may apprehend the formation of fibrous bands in the vitreous, and these may ultimately result in detachment of the choroid and retina. Infected wounds often lead to panophthalmitis.

*Treatment.*—In rupture of the choroid from contrecoup but little can be done. It is probably best to put the patient to bed and to give remedies that will prevent the development of plastic processes or the organization of plastic products. If left without treatment the clot and exudation will become absorbed, and almost if not quite as favorable results will be obtained.

*Prognosis* is favorable.

In clean, lacerating wounds the eyeball can often be saved by properly caring for it.

Infected wounds result in panophthalmitis, which should be treated as heretofore advised.

John E. Weeks.

**Chorology.**—From χῶρος, a place or district; a term proposed by Haeckel to denote the branch of science which treats of the geographical and topographical distribution of animals and plants. In it is included a consideration not only of the habitats of the several genera and species, but also of the succession of organisms in geological history. See *Biology*.

**Chromatokinesis.**—See *Caryorrhexis*.

**Chromatolysis.**—See *Caryolysis*.

**Chromatopsia.**—Chromatopsia is a modification of the visual sensation, as a result of which all objects appear of a certain color (red, purple, blue, yellow, green, white), without any effect upon the acuteness of vision or any visible changes in the fundus.

*Erythropsia* (*red vision*), the most common variety, is not infrequent after cataract extraction, taking place in three to five per cent. of cases (Becker); it occurs also after exposure to intense light, for example, sunlit snow fields especially in high regions, brilliant electric light, flashes of lightning, and observation of the sun. This visual disturbance becomes more marked when the illumination is suddenly diminished, as after going from the open into a house. After cataract extraction there is less frequently purple or *blue vision* (*cyanopsia*), or the patient complains of objects appearing of a glaring white. The phenomenon generally appears some days after the operation; it lasts a variable number of hours, days, or weeks; it is usually intermittent but may be almost constant; it generally disappears in the course of a few days or weeks. No treatment is called for beyond the wearing of smoke-tinted glasses.

Independently of cataract extraction, the occurrence of colored vision is favored by dilatation of the pupil, congenital coloboma of the iris, iridectomy, by excitement of any sort, and by elevation of body-temperature. Red vision is an infrequent symptom of optic-nerve atrophy, glaucoma, nyctalopia, migraine, hysteria, exhausting diseases, and severe fevers; it sometimes occurs with intraocular hemorrhage; it may be part of the epileptic aura; it is said to be caused by coffee in rare instances. Blue vision is quite rare; it is occasionally complained of by patients suffering from hysteria, retinitis albuminurica, or detachment of the retina, and may also follow the use of cannabis indica. *Green vision* (*chloropsia*) is a rare symptom of detachment of the retina, optic-nerve atrophy, and aphakia as the result of cataract extraction. Blind eyes occasionally are conscious of colored lights, probably due to irritation of the visual centers.

It seems probable that chromatopsia may be due either to central irritation or to local causes. No entirely satisfactory explanation of the phenomenon has yet been offered. Fuchs attributes red vision to the action of strong light on the visual purple and its slow regeneration under less intense light; but the absence of visual purple at the macula upsets this theory; his experiments proved, however, that the phenomenon probably depends upon local causes in most cases, since when one eye was covered and protected from the influence of strong light, the resulting erythropsia affected only the exposed eye. Snellen believes it to be due to the coloring of white light by its passage through the translucent and vascular lids and choroid, and the subsequent diffusion of this reddish light over the retina; after the extraction of cataract, upon exposure to bright light, the lids are partly closed; there is thus a small central pupillary opening for white light, while the periphery of the retina is flooded with red light which has come through the lids; when the intensity of the illumination is reduced, the red perception of the periphery changes to a complementary green as a result of fatigue, while central vision appears red by contrast. The blue vision after cataract extraction is attributed by Burnett to fatigue of the retina as a result of long-continued exposure to light rendered yellow by passage through amber-colored cataracts, giving blue as a residual sensation in white light.

*Toxic Chromatopsia.*—Colored vision, usually yellow (*xanthopsia*), is one of the symptoms of the poisonous effects of certain drugs, of which santonin is the most common example; this agent may, however, produce green vision, or rarely red or blue vision. Other agents which may produce chromatopsia are amyl nitrite, picric acid, chromic acid (as a result of local applications), osmic acid, digitalis, carbonic oxide, illuminating gas, and possibly tobacco. Xanthopsia also occurs as an early symptom of catarrhal jaundice, being due probably to the discoloration of the dioptric media by bile pigments; it is seen after

dazzling from electric light, and may accompany nyctalopia. CHARLES H. MAY.

**Chromidrosis.**—*Synonyms:* Ephidrosis tincta; stearrhea or seborrhea nigricans; pityriasis nigricans; Fr., *Cyanopathie cutanée.*

DEFINITION.—A disorder of the perspiratory glands in which the sweat assumes various shades of color, as blue, red, yellow.

This is an exceedingly rare disease, so rare that many doubt its existence, but so many well-authenticated cases have been reported that further doubt is scarcely warranted. On the other hand, some of the cases observed have proved to be impostures.

The disease is most frequently observed upon the eyelids, cheeks, forehead, abdomen, and scrotum. The distribution may be unilateral or symmetrical, the disease occurring in small patches. Often the affected area changes from place to place. The color varies from a yellow to a dark brown, brick-dust-like, green, blue, or red tint. There is usually mixed with the sweat a certain amount of fat which upon drying leaves an amorphous granular deposit upon the skin, and which may be partially if not entirely removed by water or ether.

Most cases have occurred in neurotic or hysterical unmarried women, in conjunction with uterine or ovarian disorders and with chronic constipation. It was formerly thought that the absorption of indican from the intestinal canal in the latter condition was the principal factor, but this has not been fully confirmed, as the pigment in the sweat does not always give the indican reaction. In a case examined histologically by Heidingsfeld, he concluded that there was an anomaly of pigmentation quite independent of the glandular secretions.

The amount of pigment in these cases varies from day to day, and may disappear for weeks or months to recur again. The disease usually lasts for years.

Green or blue sweat occurs quite frequently in workers in copper, from internal introduction of the metal. Blue sweat has been known to occur after taking large quantities of iron and also of potassium iodide; in the latter case the blue reaction was caused by the starch in the shirt (Taylor).

Phosphorescent sweat has been observed after taking phosphorus and after eating phosphorescent fish.

Red sweat occurring in moist regions of the body like the axilla and pubes is produced by microorganisms (*Bacterium prodigiosum*), and is associated with concretions on the hairs (lepothrix).

Hematidrosis cruenta is produced by hemorrhage into the sweat glands or ducts, causing a reddish sweat.

TREATMENT.—The treatment of chromidrosis depends upon the cause. In the idiopathic forms the general condition should be treated—bowels, uterine conditions, etc.

In those cases which are due to the introduction of metals or drugs into the system the treatment is obvious.

The forms produced by microorganisms can be easily relieved by mild antiseptic applications.

WILLIAM A. HARDAWAY.

**Chromium.**—Chromium belongs, chemically, to the same group of elements as iron and manganese. Its symbol is Cr, atomic weight 52, and its valence is II. or IV., but in the latter case the atoms do not enter into combination singly but grouped two together to form a hexavalent unit, as in the case of chromic oxide $Cr_2O_3$.

Chromium is a hard, crystalline, metal, found in combination with iron. Compounds of chromium are constitutionally highly poisonous, and chromic acid and its soluble salts are also intensely irritant, and even caustic. Medicinally, preparations of the mineral are used for local purposes. The United States Pharmacopœial compounds are the following:

*Chromii Trioxidum.*—Chromium Trioxide, $CrO_3$. This compound is in "small, needle-shaped crystals, or rhombic prisms, of a dark purplish-red color and metallic luster: odorless; destructive to animal and vegetable tissues; deliquescent in moist air. Very soluble in water, forming an orange-red solution. When brought in contact with alcohol, ether, glycerin, and other organic solvents, decomposition takes place, sometimes with dangerous violence." (U. S. P.) On heating, chromium trioxide first fuses to a reddish-brown liquid, and then decomposes into green chromic oxide and free oxygen. Because of its powerful chemical action, chromium trioxide should be kept in glass-stoppered bottles and never brought into contact with any kind of oxidizable organic matter. In concentrated application it is a powerful and penetrating caustic, and is available in surgery when a deep and thorough cauterization is demanded. But it should not be applied over an extensive area, lest enough be absorbed to produce constitutional poisoning. It is generally used by mixing the crystals with a drop of water to the forming of a paste. Chromium trioxide is also a powerful oxidizer and antiseptic, thus proving disinfectant, both by destroying low forms of living things, and also by oxidizing foul products of zymotic processes. But its corrosive properties make the disinfectant virtues generally unavailable. It is of use, however, for the preservation of organic tissues in the laboratory, particularly nerve structures intended for microscopical examination, since it both preserves and somewhat hardens the specimen while changing but little its histological appearance. It is used for such purpose in very weak aqueous solution. Chromium trioxide should not be prescribed for internal medication, and, in prescription for any purpose, the explosiveness of its mixture with glycerin and other oxidizable matters must carefully be borne in mind. Chromium trioxide has been employed externally in one-per-cent. solution to toughen the feet of soldiers on the march.

*Potassii Dichromas.*—Potassium Dichromate ($K_2Cr_2O_7$). This well-known salt is in "large, orange-red, transparent, triclinic prisms or four-sided tabular crystals, odorless, and having an acidulous, metallic taste. Permanent in the air. Soluble in about nine parts of water at 25° C. (77° F.), and in 1.5 parts of boiling water; insoluble in alcohol." (U. S. P.) On heating, the salt first fuses to a dark-brown liquid, and then decomposes into neutral potassium chromate and green chromic oxide, with evolution of free oxygen. Potassium dichromate is severely irritant and poisonous, and is not used in medicine. In weak aqueous solution it is a convenient preservative for histological specimens, producing effects similar to those of chromium trioxide. Potassium dichromate has been employed in cases of gastric ulcer and gastric catarrh, in doses of one-sixth grain (0.01). *Mueller's fluid* is compounded of from two to two and a half parts of potassium dichromate and one part of sodium sulphate, dissolved in one hundred parts of water. Potassium dichromate is official in the Pharmacopœia for use, in solution, as a chemical test.

TOXICOLOGY.—All soluble compounds of chromium are poisonous. The compounds of most toxicological interest are the trioxide, commonly called chromic acid, $CrO_3$, the dichromates such as the sodium and the potassium dichromate, $K_2Cr_2O_7$, and the neutral chromates, potassium chromate, $K_2CrO_4$, and lead chromate, $PbCrO_4$. Potassium dichromate is the common red salt of commerce, and has caused more

fatal cases of chromium poisoning than any of the other compounds of this metal. Chrome yellow, normal lead chromate, and chrome red, a basic salt, are capable of causing chromium poisoning if ingested in sufficient quantity at one time, but when taken in small quantities through long periods of time the symptoms are those of chronic lead poisoning. The salts of chromium, such as chrome alum, $KCr(SO_4)_2$, are not known to have produced poisoning in man. The form of poisoning due to the local action of the dust of the chromates is not uncommon in factories where these chemicals are used, but cases of acute poisoning are infrequent, though a considerable total number has been reported. The cases have been largely accidental, though there have been some suicides, and in some the dichromate has been taken as an abortifacient.

*Acute Poisoning.*—The alkaline chromates are readily absorbed after ingestion, and produce symptoms which, together with those due to the local action in the stomach and intestines, give a marked type of acute poisoning. The salts have a metallic, bitter taste. The symptoms produced by them are, first, those of a severe gastroenteritis; nausea, vomiting of yellow-colored material which may be bloody; diarrhea, and even bloody movements; thirst; abdominal pain; colic; tenesmus; cramps in the legs; great anxiety and prostration; cold and clammy skin; rapid and feeble pulse. These symptoms are followed by pain in the region of the kidneys accompanied by the passage of albuminous bloody urine containing renal tube casts, or even by suppression of the urine. The respiration becomes feeble and irregular, the patient loses consciousness and dies in coma or convulsions. If the fatal result is delayed beyond the first day, jaundice appears as a result of fatty degeneration of the liver. In some cases the gastrointestinal symptoms are not as prominent as in the typical case, and they may be wanting. If the case be prolonged the symptoms referable to the kidneys and bladder and to the liver, become more prominent. Death has resulted in from forty minutes to ten days; the average duration of fatal cases is about eight or nine hours.

Postmortem Appearances.—The signs of inflammatory action are usually found in the alimentary tract, though they may be absent. These signs have been observed in all portions of the tract and have indicated all grades of intensity of action: hyperemia, swelling, ecchymoses, brownish injection of the mucous membrane, corrosion, and ulceration. Signs of inflammatory action have also been found in the bladder, the lungs, the endocardium, and the pericardium. The kidneys have been reported as hyperemic and as showing structural changes in the epithelium of the tubules with abundant cast formation. Fatty degeneration has been observed in the liver and heart muscle, and the blood has been found viscid and very dark. The dark appearance is said to be due to the presence of methemoglobin (Priestley). The gums may show a bluish-gray line about the teeth which is ascribed to the reduction of chromic acid to chromic oxide, $Cr_2O_3$.

Fatal Dose.—Falk mentions four cases of recovery after doses varying from 0.25 to 4 grams (4 to 60 grains), and recovery has followed doses up to two ounces in cases properly treated. The smallest dose known to have been fatal to an adult was two to three grams (31 to 46 grains); the man died in ten days.

Treatment.—The first indication in acute poisoning is the neutralization and removal of the poison. The acid salt may be converted into the less irritating neutral chromate by the administration of magnesia or sodium bicarbonate. Lead acetate has been recommended with the view of forming the difficultly soluble lead chromate, but it should obviously be used with caution. More important than these chemical antidotes is prompt removal of the contents of the stomach by the use of emetics if there is little vomiting, but better by very thorough washing with the stomach tube. The subsequent treatment of the gastroenteritis is that of the inflammation caused by metallic poisons in general, though subnitrate of bismuth would seem to be specially indicated because of the nearly insoluble bismuth chromate that would be formed with the traces of poison remaining.

*Chronic Poisoning.*—The occurrence of a chronic general poisoning due to the absorption of small amounts of chromate is questionable. There has been abundant opportunity for the occurrence of cases of such poisoning among employees in factories where chromates are largely used, but no chronic condition ascribable to this cause has as yet been observed in man. It is possible that the rapid elimination of the chromate is a sufficient protection in the case of man against the effects of small doses, but as a chronic intoxication has been produced in dogs by very long-continued action of chromates (Viron), the possibility of its occurrence in man should be recognized.

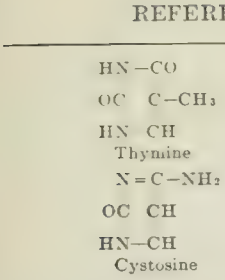
EDWARD CURTIS.
R. J. E. SCOTT.

**Chromomonadidea.**—Chrysoflagellida, a suborder of flagellate protozoans, subclass *Phytomastigophora*, in which the animals possess brown chromatophores. See *Protozoa*.

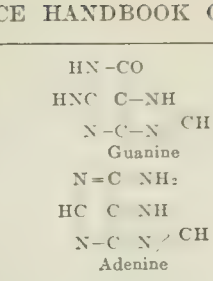
A. S. P.

**Chromosomes.**—(χρῶμα, χρῶματος, color, and σῶμα, a body.) The substances forming the nucleus of a cell may be roughly divided into two groups. One of these is distinguished by the ease with which the material may be colored with the basic dyes, while the other, like most cytoplasmic structures, is not readily stained with these dyes. The former is called *chromatin*, the latter *achromatin*. During the stages preparatory to the mitotic division of the nucleus the chromatin becomes segregated into a definite number of portions. To the bodies thus formed Waldeyer (1888) gave the name, *chromosomes*.

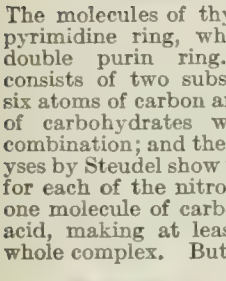
The difference in staining reactions that the chromosomes exhibit when compared with most of the other structures in the cell indicates a difference in chemical or physical condition. If a quantity of yeast, pus cells, nucleated red blood corpuscles, or other ordinary cells be subjected to artificial digestion with pepsin and hydrochloric acid, the albumins are dissolved and may be removed, leaving a residue which is more or less soluble in weak alkalies and may be precipitated by hydrochloric acid. After being purified this residue is found to be a colorless, amorphous substance insoluble in alcohol and ether, and insoluble or very slightly soluble in water, pepsin and hydrochloric acid, or in weak mineral acids. Microscopical examination of the undissolved residue shows that it consists chiefly of nuclear material, and the chemical substance which is isolated after purification has accordingly been named by Miescher *nuclein*. True nuclein is further characterized by its property of giving off xanthin bodies when boiled with dilute acids; and when treated with an alkali it is split into two substances, an albumin and *nucleic acid*, as was shown by Altmann. Kossel (1911) has been able to split nucleic acid into a number of constituents which may be divided into two groups—nitrogenous and non-nitrogeneous. In the nitrogenous group there are four subtances—Cystosine, Thymine, Guanine, and Adenine. The molecular structure of these substances, as revealed by the investigations of Emil Fischer, is represented by the following formulæ:



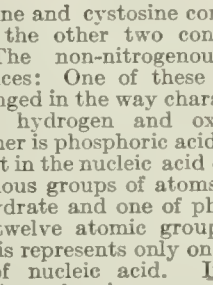
Thymine



Guanine



Cystosine



Adenine

The molecules of thymine and cystosine contain the pyrimidine ring, while the other two contain the double purin ring. The non-nitrogenous group consists of two substances: One of these contains six atoms of carbon arranged in the way characteristic of carbohydrates with hydrogen and oxygen in combination; and the other is phosphoric acid. Analyses by Steudel show that in the nucleic acid complex, for each of the nitrogenous groups of atoms there is one molecule of carbohydrate and one of phosphoric acid, making at least twelve atomic groups in the whole complex. But this represents only one variety of nucleic acid. Investigations of various organisms and of various organs of the same individual indicate that nucleic acid is not a single substance but a whole group of substances which exhibit one general plan of molecular structure with many variations. Both nuclein and nucleic acid are stained readily with the basic aniline dyes. While similarity of staining reaction does not necessarily indicate similarity of chemical composition, and the reaction of parts of a cell depends largely upon its previous treatment, the evidence as a whole goes to show that the chief chemical substance by which the chromosomes are distinguished from other structures in the cell is nucleic acid.

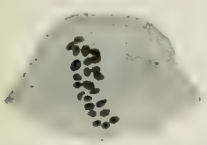


Fig. 1399.—Spermatogonium of the Earthworm (Lumbricus), Showing the Mitotic Figure in the Late Prophase. Twenty-four of the thirty-two small chromosomes may be seen gathered at the equator of the spindles. × about 1,600. (After Calkins.)

In form and structure the chromosomes differ greatly in different organisms, in different cells, and in different stages of development of the same organism. The chromosomes appear in their simplest form in the ordinary multiplicative cell divisions, where they vary from minute globular or elliptical bodies (Fig. 1399) to elongated rods, usually bent in a V- or a U-shape (Fig. 1403). In the maturation divisions of the reproductive cells, Flemming (1887) distinguished two kinds of mitoses: (1) homeotypical, in which the chromosomes are like the usual type, only shorter; and (2) heterotypical, in which the chromosomes assume a great variety of forms (Fig. 1400) such as rings, crosses, tetrads, etc. (See article, *Maturation*.)

Fig. 1400.—Forms Assumed by Chromosomes during Division of first Spermatocyte of Sagitta. (After Stevens, 1910.)

Many observers have noticed that, when highly magnified, in numerous cases the chromosomes may be seen not to be homogeneous, but to be composed of smaller units, minute granules of chromatin (Fig. 1401). In a salamander, Batrachoseps, Gustav Eisen (1900) describes the chromosomes as being composed of a homogeneous chromoplasm containing a definite number of minute bodies, which he calls *chromioles* (Fig. 1403) and believes to be fundamental elements of the nucleus. These are arranged in two rows, one on each side of the chromosome. The latter is constricted slightly at regular intervals, and is thus divided into segments, or chromomeres (Fig. 1402). In the fully developed chromosome of this species there are six chromomeres, each containing six chromioles.

Chromosomes, as a rule, appear only during cell division and their origin and fate are intimately associated with that process, for a description of which the reader should consult the article on the *Cell*.

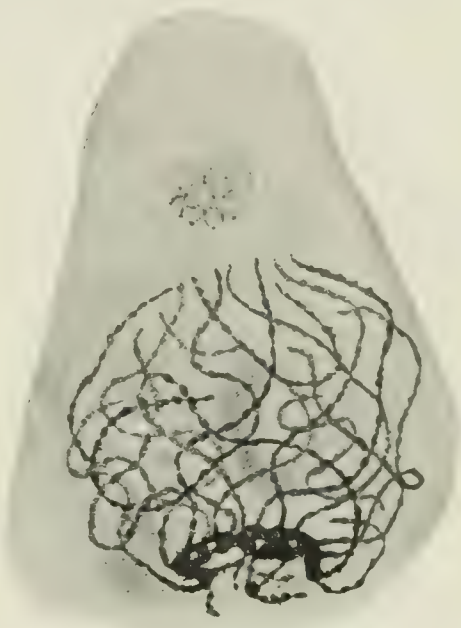


Fig. 1401.—Primary Spermatocyte of Batrachoseps. Nucleus in the spireme stage. One or two large chromoplasts are seen in the lower part of the nucleus. ×about 1,500. (After Eisen.)

When, after a resting stage, the nucleus again prepares for division, the chromosomes which reappear within it are of the same number as those of which it was originally formed.

There is great variation among the various species of plants and animals in the number of chromosomes, but the number in each species is characteristic. It was thought formerly that the number in the somatic cells, the *diploid* number, is always even, and the number in the ripe germ cells, *haploid* number, is equal in both sexes and just one-half the diploid number (Wilson, 1900, pp. 205–207). Studies on the spermatogenesis of the bugs (Hemiptera) and grasshoppers have led, however, to important modifications of this view.

In 1890 Henking found in the bug Pyrrhocoris that there are two kinds of spermatozoa, one of which contains a body that stains like chromatin but which he regarded, nevertheless, as a nucleolus. In 1898 Montgomery found a similar "chromatin nucleolus" but thought then that it was divided equally among all the spermatids. The next year Paulmier described the spermatogenesis in the squash bug, Anasa, where, in the last spermatocyte division, one chromosome goes over undivided into one of the daughter cells; with the result that half of the spermatozoa contain one chromosome more than the other half. But he became confused as to the details of the process. During the same year, McClung (1899) published the results of similar observations on a green grasshopper, Xiphidium, and gave the name, *accessory chromosome* to the odd one. To McClung is due the credit of having first suggested

(1902) that the accessory chromosome is concerned in the determination of sex. (See article, *Sex*.)

In 1901 Montgomery had published the results of the study of spermatogenesis in forty-two species of bugs and suggested that the chromosomes of the diploid group are present in pairs, which unite in synapsis (see article, *Maturation*), and that of each pair one member is of paternal and the other of maternal origin. These conclusions, as well as McClung's, were confirmed in a striking manner by Sutton in his remarkable paper of December, 1902,

Fig. 1402.—First Spermatocyte of Batrachoseps in a Stage Immediately Preceding the Metaphase. Eight of the twelve chromosomes are seen approaching the equator of the spindle. × about 1,500. (After Eisen.)

on the giant grasshopper, Brachystola. In September, 1905, Miss Stevens announced that she had been able to find in the meal worm (larva of the beetle, Tenebrio) not only sexual differences in the germ-cells, but also differences in the chromosomes of the somatic cells of the two sexes; and in October, Wilson, in a general review of the whole subject, stated that there could be no doubt that there is a definite relation of some kind between chromosomes and sex in the Hemiptera and, presumably, also in other animals. This conclusion has been abundantly confirmed by the extensive and brilliant researches of Morgan, Miss Stevens, and Wilson, not to mention important contributions by a host of other workers, both in this country and abroad.

This relation between chromosomes and sex will be considered more in detail elsewhere (see articles, *Maturation* and *Sex*), but here should be noted the general conclusion that there are two classes of chromosomes—(1) *Autosomes* (Montgomery, 1906), the ordinary chromosomes, which, so far as known, are always present in equal numbers in the germ-cells. (2) *Allosomes* (Montgomery, 1906) which are fewer in number, differ from the autosomes in appearance or behavior, or in both, and may be unequally distributed among the germ-cells (syn. *Heterochromosomes*, Montgomery, 1904). Montgomery proposed to divide the allosomes into two groups: a. *Monosomes*, allosomes which are unpaired in the spermatogonium (syn. *Accessory chromosomes*, McClung, 1899); and b. *Diplosomes*, allosomes which

Fig. 1403.—First Spermatocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

Fig. 1404.—First Spermatocyte of Batrachoseps in the Late Anaphase, Daughter-chromosomes Collecting at the Poles of the Spindle. × about 1,500. (After Eisen.)

are paired in the spermatogonium. But, as pointed out by Wilson (1909 *b*) this classification is unsatisfactory because too artificial.

The allosomes are better divided into: (1) *M-chromosomes* (Wilson, 1905 *c*), a pair of small chromosomes (Fig. 1405) found in the cored Hemiptera, which are distinguished by the fact that they remain distinct during the periods of synapsis and growth,

and conjugate only in the final prophases of the first spermatocyte division. They are distributed equally to all the spermatozoa. Their significance is unknown (syn. *Small Chromosomes*, Paulmier, 1899; *chromatin nucleoli*, Montgomery, 1901, etc.). (2) *Idiochromosomes* (Wilson, 1905 *a* and 1909 *b*) the chromosomes that form the distinctive differential between the chromosome groups of the two sexes, and between the male-producing and the female-producing spermatozoa.

Of these we may distinguish the X-*element* (Wilson, 1909 *a*) which may consist of one, two, or more chromosomes and is always present in one spermatozoön of each pair; and the Y-*element* which may be absent and, when present, is the synaptic mate of the X-element and goes to the other spermatozoön of the pair. The X-element when single and not accompanied in the spermatogonium by a Y-element, has been called *accessory, odd*, or *heterotropic chromosome, monosome*, and *unpaired idiochromosome*. When the X-element is single and a Y-element is present, the former has been called the *large* and the latter the *small idiochromosome*. It is supposed that, when an egg is fertilized by a spermatozoön containing the X-element, a female is produced, and when this element is absent from the spermatozoön, a male is the result.

Fig. 1405.—Polar Views of Chromosome Group in first Spermatocyte of Metapodius. *I*, X-element; *i*, Y-element; *m*, *M*-chromosome. × 3,300. (After Wilson, 1909.)

The investigations outlined in the preceding paragraphs have made useless all previous estimates of the chromosomal numbers, and have reopened the whole question. The presence of idiochromosomes in man was discovered by Guyer (1910). He found in the spermatogonia twenty-two chromosomes, (Fig. 1406) of which twenty are autosomes and the remaining two form a double X-element; so there result two kinds of spermatozoa in equal numbers, one containing ten, and the other twelve chromosomes. He infers that the somatic number in the man will be twenty-two and in the woman twenty-four. These results are confirmed by Montgomery (1912), who finds, in addition, however, a surprising amount of variation in the behavior of both the autosomes and the idiochromosomes. He describes the latter as of unequal size and the smaller one as sometimes acting like a Y-element, so there are four kinds of spermatozoa, instead of two. It is difficult to reconcile either of these results with the findings of Weiman (1912), who has counted the number of chromosomes in the dividing somatic cells of a normal nine-millimeter human embryo of indeterminate sex. The number varies from thirty-three to thirty-eight, thirty-four being the most frequent (Fig. 1407). Still more diverse are the results of von Winiwarter (1912). He finds in human spermatogonia forty-seven chromosomes, including a single X-element, and the resulting spermatozoa to be of two kinds containing twenty-three and twenty-four chromosomes respectively. These results differ so much from all others that they may be suspected of being due either to errors of observation or to the presence of a rare abnormality.

A B

Fig. 1406.—Cells from a Human Testis. *A.*, Polar view of prophase of spermatagonial division, with twenty autosomes in a circle and two idiochromosomes in a vacuole at one side; *B.*, Side view of metaphase in division of a first spermatocyte, with the autosomes massed in the equatorial plate and the idiochromosomes nearer one pole of the spindle. (After Guyer, 1910.)

That interesting parasite, *Ascaris megalocephala*, presents a curious exception to the law of the number of chromosomes. The mature germ cells of this species have only one chromosome (var. *univalens*), or two (var. *bivalens*), and the first blastomeres in the dividing ovum have correspondingly two or four chromosomes. This is true also of the cells which in later stages are destined to form the germ cells for the next generation. But in the subsequent divisions of the purely somatic cells the chromatin becomes divided into a large number of very minute chromosomes; it is probable, however, that the number is constant.

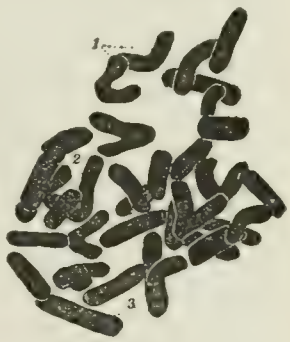



Fig. 1407.—Group of Chromosomes, thirty-four in number, in a dividing liver cell from a human embryo. 1, 2, 3, synaptic pairs. Highly magnified. (After Wieman, 1913.)

Only in rare instances do the chromosomes persist intact from one cell-division to the next. Still there are a number of facts which seem to indicate that the chromosomes which appear preparatory to the division of a nucleus are individually the same as those which formed that nucleus after the previous division.

The evidence for this view may be considered under three heads: 1. The correspondence between the number of chromosomes entering into the formation of a nucleus and the number issuing from it. 2. The correspondence in position between the place of disappearance of the chromosomes and the place where they reappear. 3. The observed distinctness of the groups of chromosomes derived from the male and female parent respectively.

The law that "whatever be the number of chromosomes entering into the formation of a reticular nucleus, the same number afterward issues from it," has been found to hold good in all normal cell-divisions that have been observed, except in the special cases of the spermatocyte and oöcyte in animals and the corresponding spore cells of plants. These special cases, which will be fully considered in the article on *Maturation*, do not detract from the force of the evidence furnished by the general rule. The force of this rule is most strikingly illustrated by certain abnormalities, especially in the eggs of Ascaris.

In the commoner variety of *Ascaris megalocephala*, var. *bivalens*, the oöcyte, or immature egg, has two bivalent chromosomes. As a result of the maturation divisions there are in the first polar body four chromosomes, two in the second polar body, two in the female pronucleus, and the spermatozoön brings in two more, making a total of ten.

The variety *univalens* presents the same phenomena except that the numbers are just one-half of these. Fortunately in these wonderful eggs the polar bodies persist until the formation of the embryo is well under way, and the chromosomes in them may be counted.

Now Boveri and Herla have shown that while development ordinarily follows the normal course, various abnormalities may occur; but, with the exception of two or three possibly doubtful cases, the total number of chromosomes may always be accounted

for according to the rule. For example, in var. *bivalens* it sometimes happens that two small female pronuclei are present instead of one large one, and when the chromosomes are formed it is found that only one chromosome appears in each of the small pronuclei, the total number remaining the same. In other eggs four chromosomes were found in the female pronucleus or six in the first cleavage spindle, but the second polar body was not to be found and had evidently not been extruded. Again, cases were found in which there were only three chromosomes in the first polar body, and the missing one was discovered in the second maturation spindle or in the female pronucleus.

Herla, however, found one female in which all the eggs showed the normal polar bodies of var. *bivalens*, but in the first cleavage spindle and subsequent stages there were only three chromosomes. But in the same intestine he found other worms of the var. *univalens*. There is strong reason to believe that this was a case of crossing, the female of one variety having been impregnated by the male of the other, and thus the rule would still hold good. In other worms from the same source a few cases were found of redundancy of chromosomes with normal polar bodies. Herla explains these as due to the entrance of two spermatozoa, which Van Beneden has shown to occur rarely. In short, all the abnormalities are susceptible of explanation in accordance with the rule, there being only two or three very rare cases in which the validity of the explanation might be questioned.

The rule is further confirmed by observations of Brauer on the parthenogenetic eggs of the crustacean Artemia, and Boveri and Morgan have made the interesting discovery that it is possible to fertilize fragments of echinoderm eggs which contain no female pronucleus and to obtain larvæ whose cells contain just half the normal number of chromosomes, the number introduced by the spermatozoon. E. B. Wilson has found that the same is true of echinoderm embryos derived from eggs which have been stimulated to develop by Loeb's chemical method without the entrance of a spermatozoon.

In all these cases, wherever the number of chromosomes in the first cleavage spindle has been altered as the result of some accident of maturation or fertilization, this same number is found to reappear in subsequent stages. Thus these abnormalities contribute striking proof of the law of equality in the number of chromosomes.

While it is true that if the chromosomes maintain their individuality in the reticular nucleus, the same number must appear at the close of the resting period as were present at the beginning, the demonstration that this is the fact does not prove that the new chromosomes contain the same elements. There may be an entire rearrangement of the chromatin during the reticular stage. Therefore, if it can be shown that, besides being equal in number, the chromosomes are reformed in the same part of the reticulum where they disappeared, we shall have greatly strengthened the evidence for their individuality.

So far the only form that has supplied such evidence is Ascaris. Here in the two-cell stage when the chromosomes unite to become the nucleus, the ends of the chromosomes project from the general mass and persist during the resting stage as reticular lobes, and the first step in preparation for the second division is the concentration of the chromatin in these same lobes to form the ends of the new chromosomes. The ends of the chromosomes in this case, therefore, appear to be composed of the same chromatin before and after the resting stage. As to whether this is true of the middle part or not the evidence is inconclusive.

Finally there is a certain amount of evidence, that if not the chromosomes, at any rate the mass of chromatin derived from each parent, remains distinct. In the hybrid eggs of Ascaris, Herla found that the female pronucleus gave rise to a single thread of chromatin which divided transversely to form the two chromosomes, while the male pronucleus produced a much shorter thread that did not divide. In subsequent divisions of the series leading to the formation of the primordial germ cells of the embryo he observed that the three chromosomes arose in the same way, indicating a persistent distinction between the chromatin of maternal and that of paternal origin.

In a little copepod, *Cyclops strenuus*, Häcker and Rückert have demonstrated that the twelve chromosomes of each germ-nucleus remain distinct and give rise in the two-cell stage to a distinct half of the bilobed nucleus of each cell. Two spiremes are formed in the next stage, producing separate groups of twelve chromosomes, and Rückert traced the maternal and paternal groups of chromosomes in this way through several successive cell-divisions and found evidence of the dual nature of the nuclei as late as the stage of the formation of germ-layers.

That the chromosomes do not lose their individuality during the resting stage still is more strikingly shown in certain fish hybrids observed by Moenkhaus (1904). In the species used for the experiment, the chromosomes differ conspicuously in shape and size, and in the hybrid embryos, although the chromosomes mingle freely in the later cleavage stages, paternal chromosomes could still be easily distinguished from those of maternal origin. This conclusion is still further strengthened by the numerous studies of normal maturation phenomena made with regard to the question of the determination of sex, to which reference has been made in the previous paragraphs.

The physiology of the chromosomes is the most difficult question that we have to consider, because experiment is wellnigh impossible, and we can draw inferences as to their functions only from the appearances observed in the various stages of cell activity.

There are a number of observations and experiments, however, to show that the nucleus plays a very important part in the economy of the cell. Thus, if the body of a unicellular organism be divided so that one part contains no nuclear material, this part may remain alive for some time but is unable to digest food or to repair the damage, while the part containing the nucleus can do all of this and soon becomes as perfect as before.

That the chromatin is the most essential part of the nucleus seems to be evident from the phenomena of mitosis. Here we see every part of the mechanism designed apparently to effect the exactly equal distribution of the material to the two daughter-cells; and when the daughter nuclei are reformed they are produced entirely by the transformation of the chromosomes. Rückert has found that in a shark, Pristiurus, the chromosomes persist during the growth period of the egg. At first they are small and stain darkly. During the growth of the egg they increase enormously in size and lose in staining capacity, and at the end of the period they contract to one-sixth of their original length and stain very darkly. "As Rückert points out, the great increase of surface in the chromosomes is adapted to facilitate an exchange of material between the chromatin and the surrounding substance; and he concludes that the coincidence between the growth of the chromosomes and that of the egg points to an intimate connection between the nuclear activity and the formative energy of the cytoplasm." "We may infer that the original chromosomes contain a high percentage of nucleic acid; that their growth and loss of staining power is due to a combination with a large amount of albuminous substance to form a lower member of the nuclein series, probably a nucleo proteid; that their final diminution in size and resumption of staining

power is caused by a giving up of the albumin constituent, restoring the nuclein to its original state as a preparation for division." Ordinarily these chemical changes and interchanges between chromatin and achromatin take place in the reticular stage of the nucleus, and the chromosomes, as they are usually observed, probably have nothing to do with them. The reticular nucleus is probably not at all in a "resting stage" but is a seat of lively metabolic activity, and it is more probable that the chromatin of the chromosomes is in more nearly an inactive condition. Why the chromatin should assume this form at the time of division is not known, but the presence of the chromosomes at almost every cell-division in the whole range of forms from the protozoa to man and the higher plants indicates that their formation is an essential step in the process.

The most important function that has been ascribed to the chromosomes is that of transmitting the physical basis of heredity from one generation to the next. Statistical studies of Galton, Pearson, and others indicate that on the whole the heritages from the two parents to the offspring are equal. There must be in the fertilized egg, then some material body derived in equal proportion from the two parents, and the chromosomes are the only bodies that so far have been found to meet this requirement. Moreover, during the first cleavage of the egg each chromosome is divided by longitudinal fission into exactly equal parts, which are distributed to the two daughter cells so that each one has an exactly equal number of chromosomes of paternal and of maternal origin. If the individuality of the chromosomes be a fact, then this equal distribution of chromatin from the two sources is extended to all the cells of the body. If we further assume as proven that the chromatin is the seat of the formative activity of the cell, then we begin to gain some insight, apparently, into the manner in which the maternal and paternal characteristics are commingled in all parts of the offspring.

Finally, a comparison of the phenomena of maturation and fertilization with the postulates of the Mendelian theory, shows a remarkable parallel between the behavior of the chromosomes and the distribution of the unit characters. This parallel is so exact that it amounts almost to a proof that the chromosomes play the leading rôle in the transmission of hereditary characteristics.

It may be asked, and with good reason, How is it possible for the complex of hereditary qualities of a gifted father to be transmitted to his distinguished son through a few ultramicroscopic threads of nucleic acid? The theories of heredity will be discussed in another article (see *Heredity*), but it may be pointed out here that nuclein and nucleic acid are the products of dead nuclei. We have no knowledge of the chemical substances in the living nucleus and in the chromosomes beyond the fact that they are so combined that when their vital activities have ceased they yield to the chemist bodies of the nuclein series. The nucleins are certainly very complex bodies, but there can be little doubt that the living chromosomes are infinitely more complex than anything we can discover with the microscope or by chemical analysis. ROBERT PAYNE BIGELOW.

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**Chrysarobin.**—CHRYSAROBINUM, U. S. P. A neutral principle, in its commercial, more or less impure form, extracted from Goa powder, a substance found deposited in the heart wood of *Vouacapoua araroba* (Aguiar) Lyons (fam. *Leguminosæ*). This, sometimes misnamed chrysophanic acid, is the crystalline substance of which "Goa powder" principally consists. It has long been used in Brazil, whence its employment has spread through Portuguese commerce to India and the East.

Goa, or Araroba, is a pulverulent substance, contained in long and large canals in the older wood of the trunks, and also in large irregular cavities in the same, formed by erosion or degeneration of the wood itself. It is obtained by cutting and splitting up the trees, and scooping or scraping out these canals and cavities. It is considerably irritating to the skin and mucous membranes, and severe inflammation of the face and eyes of those who collect it is not unusual. Lacrymation and sneezing are readily produced by sifting or handling the powder. Crude Goa is a rather coarse powder, mixed with lumps and fine bits and fibers of wood, varying from dull yellow (when fresh) to reddish brown, or even a greenish or violet-brown color, with the other properties of its purified product as described below. Besides small amounts of sugar, gum resin, and cellular tissue, it contains, as was first shown by Professor Attfield, eighty-five per cent. of a yellow crystalline substance, which he supposed was *chrysophanic acid*, but which Lieberman afterward proved to be a mixture consisting mostly of a peculiar substance, *chrysarobin*, having many points of resemblance to the above-mentioned acid, containing a little of it, and, in fact, capable of being transformed into it

by oxidation. Chrysarobin is a pale, orange-yellow, microcrystalline powder, odorless and tasteless, turning brownish yellow on exposure to air; very slightly soluble in cold water or alcohol; soluble, without leaving more than a small residue, in 150 parts of boiling alcohol; also soluble in thirty-three parts of boiling benzol, and in solutions of the alkalies.

Chrysarobin taken internally, is an active irritant to the alimentary canal, causing violent and persistent catharsis and vomiting. It is eliminated, partly unchanged and partly converted into chrysophanic acid, by the kidneys, which glands are extremely irritated by it, and hematuria and interstitial nephritis may follow. It is, however, here never given internally, its use being confined to local applications as an irritant and parasiticide in chronic psoriasis, pityriasis versicolor, and tinea tonsurans. It produces an active acute inflammation, which as it subsides leaves the original malady in an improved condition. Chrysarobin stains both skin and clothing badly. Its contact with the eye has caused conjunctivitis, iritis, and subepithelial corneal opacity. Chrysarobin should not be applied where inflammation already exists. The ointment (*Unguentum Chrysarobini*, U. S. P., strength six per cent.) is of a suitable strength for inunction. H. H. Rusby.

**Chrysoflagellida.**—See *Chromomonadidea.*

**Chrysoidin.**—A name given to diamidoazobenzol hydrochloride. It is a reddish-brown, crystalline powder, made from aniline; and, in solution, is used as an antiseptic mouth wash. R. J. E. Scott.

**Chrysomyia.**—A genus of flies. The larva of *C. macellaria* is the dreaded screw-worm, which ranges through America from Canada to Patagonia, and is especially troublesome in the tropics. The eggs are deposited on the surface of wounds or in the nasal fossæ of persons sleeping in the open air, especially of those having offensive discharges which attract the fly. The larvæ hatch in a few hours and burrow in the tissues, causing severe inflammation and not infrequently death. See *Insects, parasitic.*
A. S. P.

**Chrysophanic Acid.**—*Rheic Acid; Rhein.* $C_{15}H_6(CH_3)(OH)_2O_2$. This is a bright yellow crystalline powder extracted from rhubarb, to which it imparts the yellow color. It is insoluble in water and only slightly soluble in alcohol, but dissolves in both ether and chloroform. It is highly irritant, and has the same properties and uses as *Chrysarobin*, which see. H. H. Rusby.

**Chrysops.**—A genus of horse flies, family *Tabanidæ*, which is readily recognized by the golden green eyes which characterize its species. These flies attack man and other animals. See *Insects, poisonous.*
A. S. P.

**Chvostek, Franz.**—Born in Vienna, Austria, in 1835. He studied medicine in the "Josephs-Akademie," a medical school in Vienna for the education of military surgeons, and completed the course in 1861. During the following two years he was connected with one of the Austrian regiments, and was assigned to duty in Garrison Hospital No. 1, in Vienna. From 1863 to 1867 he was Duchek's assistant (in the Medical Clinic of the Josephs-Akademie); from 1868 to 1871 he delivered seventy-one lectures on electrotherapeutics in that school; and from 1871 to 1874, when that institution was permanently closed, he conducted the Medical Clinic in the place of Professor Duchek. His death occurred on November 16, 1884.

Chvostek was highly respected by his professional brethren as a conscientious, humane, and most industrious physician. He had a large practice, and contributed no fewer than 136 articles, covering the entire field of internal medicine, to current medical literature. A. H. B.

**Chylangioma.**—A name applied to tumors the substance of which is for the most part composed of the radicles of the thoracic duct. By some writers all forms of chylous cysts of the mesentery and intestinal wall are included under the term chylangioma. Mesenteric chylous cysts may be placed in three groups according to their etiology. A not infrequent sort includes those which arise as a result of obstruction of the thoracic duct or its radicles. Obstruction may be caused by occlusion of the duct resulting from tuberculosis or malignant change, or by pressure from without due to aneurysm or tumor. In the second group may be placed chylous cysts which follow chronic inflammatory processes in the intestinal wall or mesentery. The third group, and the only one to which the term chylangioma should be applied, includes those true neoplasms which are comparable to the lymphangiomas formed elsewhere in the body and which differ from them only in that they contain a chylous fluid instead of lymph.

The true chylangiomas vary in size from those barely visible to those which are as large as a man's head. They are found in the intestinal wall and between the peritoneal layers of the mesentery. They may be single or multiple. According to the size and character of the chyle channels found in the tumor mass one may differentiate *chylangioma simplex*, *chylangioma cavernosum*, and *chylangioma cysticum*, these terms having the same significance as in the case of the ordinary lymphangiomas.

The chylous cyst and cystic chylangiomas contain a whitish or yellowish-white fluid which, upon standing, becomes opalescent in its upper layers. Very rarely the contents are caseous in nature. These cyst fluids have been shown to contain minute fat droplets in suspension, fatty acids, cholesterin, and the other constituents of chyle. In this way it has been possible to differentiate between chylangiomas and lymphangiomas by establishing the identity of the chylous contents of the former.

The symptomatology of chylangioma depends almost entirely upon pressure symptoms. The physical findings are often obscured by the presence of a tympanitic percussion note over the abdominal tumor. This finding depends upon the interposition of coils of intestine or the stomach between the chylangioma and the abdominal wall. As emphasized by Proust and Monod, the apparently latent character of the neoplasm and the very tardy appearance of pain or of other signs of intestinal disease are points of great clinical importance. The possibility must be borne in mind that intestinal obstruction may result from the presence and growth of a large chylangioma. The presence of a fluctuating retroperitoneal tumor which yields a chylous fluid upon aspiration is of the greatest differential importance.

The treatment of chylangioma is of course surgical. The prognosis after interference is largely determined by the extent of the new growth and by the age of the patient. Carl Vernon Weller.

**Chyle.**—(χυλός, juice, derived from χέω, I flow, and identical in meaning with χυμός, chyme, from the same root.) The ancients employed both chyle and chyme to indicate more or less digested alimentary contents, apparently without much discrimination, although some say that the terms were used in the

reverse of the more modern meanings (*i.e.* chyle for gastric and chyme for intestinal contents). Until recently, the term chyle has been used both for the normal emulsion formed in the small intestine and for the milky contents of the lymphatics leading from it. At present, the tendency is to limit the term to the latter sense. However, as the preabsorptive or intestinal chyle necessarily influences the composition of the postabsorptive or lymphatic chyle and, indeed, is the source of the fatty matters which distinguish the latter from lymph in general, it seems proper to retain the double meaning so long in vogue.

The chyme begins to enter the duodenum shortly after ingestion, at first consisting mainly of watery contents only slightly acid and undigested except for the action of ptyalin on cooked starches. The discharge continues intermittently, the acidity and degree of digestion increasing gradually. While the pylorus theoretically contracts upon any solid, undigested masses, these also gradually escape into the duodenum. One hour after a pultaceous, cereal meal, amounting to say 50 to 100 grams of some breadstuff or cereal in the limited sense, and with beverages up to 250 c.c., in spite of the addition of gastric juice, the total residue in the stomach is reduced to about 100 c.c. and, in another hour, the whole meal will have passed into the intestine. The delay in the stomach varies somewhat according to the acidity and time required for digestion to a pultaceous mass but, after a mixed meal aggregating 250 to 500 c.c., the stomach should be entirely empty within from three to five hours, and after even a very large meal of 1,000 c.c. including a variety of solids and beverages, the stomach should be empty within eight hours.

The term chyme is retained so long as the contents preserve their acidity and until the gastric digestive processes have been superseded by intestinal, that is, until there has been sufficient admixture of bile, pancreatic and intrinsic intestinal juices to neutralize the free and combined HCl, to stop the action of pepsin, to allow the action of pancreatic and intrinsic intestinal ferments to begin, and to emulsify the fats with the aid of the biliary salts. While it is conceivable that these changes may occur even higher than the opening of the common bile and pancreatic duct in the descending portion of the duodenum, the passage through the duodenum is usually rapid so that true chyle does not exist until the jejunum is reached and the very name jejunum (empty) indicates that peristalsis still continues at a fairly rapid rate so that the main accumulation of intestinal chyle and the progress of intestinal digestion occur rather in the lower parts of the small intestine, though there is neither anatomical nor physiological demarcation between jejunum and ileum. The alkalinity of the three juices, bile, pancreatic secretion, and intrinsic intestinal secretion, is due to carbonates so that the neutralization of chyme is attended with the formation of a considerable amount of carbon dioxide which stimulates peristalsis and lightens the intestinal contents. Chyle is not strongly alkaline. While the intestinal secretion, constantly added to its exterior, is faintly so, acid fermentation takes place to some degree in its interior and the chemical interaction, with production of carbon dioxide, continuing, maintains an aggregate reaction near the neutral point but varying, not only with regard to the relative position of any one particle of intestinal contents with reference to the cross-section of the intestine, but according to various circumstances tending to increase alkaline secretion on the one hand and acid fermentation or alkaline putrefaction on the other.

Barring the influence of strongly colored foodstuffs, chyle, on account of consisting in part of a fatty emulsion, is usually of a white, milky color and of soft consistence unless indigestible particles are present, as usually on a diet rich in certain fruits and vegetables. For example, in a case in which the stomach tube accidentally passed the pylorus, five hours after a meal of milk toast and a little jelly, the stomach itself being empty, 500 c.c. of milky chyle were obtained, free from starch and sugar, containing a little albumin and peptonized protein, but consisting mainly of a nearly neutral emulsion of fat, resisting sedimentation and putrefaction for several weeks. Similar samples are obtained from fistulæ, with due regard for variations due to diet. The same applies to postmortem examinations in cases of sudden death but, on account of obvious dietetic and pathological reasons, not to postmortems in most cases of disease.

The detailed description of the chemical and other changes occurring in the intestine will be considered in the article on *Digestion*.

Postabsorptive or Lymphatic Chyle.—In the jejune state, the lymph contained in the intestinal absorbents does not differ essentially from the contents of the lymphatics generally. Carefully collected, it contains no erythrocytes but only lymphocytes, derived from the lymphatic glands. These vary considerably in number but average about 8,000 per cubic millimeter. It coagulates, as does blood, but more slowly and less firmly, the process being subject to the same explanations, still *sub judice*, as for blood. While blood plasma consists of about 90 per cent. of water and 10 per cent. of solids, lymph contains about 94 per cent. of water and 6 per cent. of solids. The latter consist of salts (sodium chloride, calcium chloride, sodium carbonate, sodium-monohydrogen phosphate) about 0.5 to 0.8 per cent.; proteins (fibrinogen, serum globulin, serum albumin) 2 to 3 per cent., up to 4 to 6 per cent. for the intestinal lymph; dextrose 0.1 per cent.; extractives, including urea, variable; fat, trace up to large amounts. Except that for sugar and salts lymph maintains approximately the same strength as blood plasma; lymph may be considered as blood plasma of approximately 50 per cent. strength, plus a variable number of lymphocytes but approximately as numerous as in blood, and relatively more so.

Chyle, as a special kind of lymph, was first definitely noted by Asellius in 1622 at a vivisection. After a few further experiments, he discovered its dependence upon the existence of fatty intestinal chyle, gave the term lacteals to the mesenteric lymphatics, in token of their containing a milky fluid, and noted that this milky appearance was absent in the fasting state. In short, save for strictly chemical demonstrations and quantitative analyses regarding the exact constituents of the matter absorbed from the intestine, he explained the nature of chyle almost as it is understood to-day.

Chyle may be defined as intestinal lymph plus fatty matter derived from the intestinal chyle and, as in the latter, occurring in the form of a fine and relatively permanent emulsion. This emulsion consists of neutral fats, with only traces of fatty acids, soaps, or glycerin, in spite of the demonstration that fat is split into its base, glycerole (which, combined with three hydroxyl groups, constitutes glycerin) and into fatty acids by steapsin of the pancreas. An analogy may be drawn to the fact that, in spite of the digestion of proteins into albumoses and peptones, these do not exist as such in the portal blood after absorption. The fatty emulsion of lymphatic chyle persists, though perhaps with some modification not well demonstrated, after passage through the mesenteric glands, and also, in spite of dilution with lymph derived from the other viscera, abdominal walls, and lower extremities, in the receptaculum chyli and major thoracic duct, until its contents are lost in the blood stream. Indeed, fats are still demonstrable in the blood plasma of the general circulation, for some time after the absorption of fats from the intestine.

Two questions here present themselves: Is (postabsorptive) chyle merely ordinary lymph plus fats,

or does it include other products of digestion; and can fatty lymph exist elsewhere than in the lacteals and the lymph-vessels to which they are directly tributary? Both of these questions may be reduced to one: Is fat the essential characteristic of (post-absorptive) chyle? As a corollary, the question arises whether all the fat absorbed from the intestine is conveyed by the lacteals.

The answers to these questions based on analysis of collected lymph and blood, are somewhat contradictory, due largely to obvious mechanical difficulties, especially that it is practically impossible to collect all of the intestinal lymph for a definite period and with the exclusion of lymph from other parts, but that reliance must be placed on thoracic duct fistulæ, occurring accidentally in man or produced experimentally in animals. With regard to carbohydrates, it may be said that, on normal dietaries, the search is limited to dextrose and that, while fluctuations do occur, they do not correspond consistently to fluctuations in carbohydrate ingestion and digestion and that the sugar content remains at about the same point irrespective of conditions favoring or tending to prevent its absorption from the intestine. Hence, we may conclude that there is no significant absorption of carbohydrates by way of the lacteals, but that the sugar content of chyle is that of lymph and the body fluids generally.

With regard to proteins, it may be said that blood plasma contains about 8 per cent., about half of which is serum albumin. Chyle, as stated, contains from 2 to 3 per cent. as for lymph generally, up to 4 to 6 per cent. of proteins. With allowance for the higher watery content of lymph in general, it would therefore appear that some albumin is actually absorbed through the lacteals, although variations corresponding to ingestion and period of digestion have not been regularly demonstrated. At the most, the absorption of protein, like that of carbohydrate, through the lacteals, is not an important factor.

Only about sixty per cent. of the fat absorbed can be accounted for in the contents of the thoracic duct. On the other hand, this deficit does not appear in analyses of the portal blood which, indeed, does not even show an appreciable increase of fat over the blood in the general circulation. It is possible that the deficit is due to escape of lymph through anastomoses with neighboring lymphatics; or under experimental conditions in abnormal human beings or animals, the analyses do not account for a delayed movement of the lymphatic current in the lacteals; or fat may be removed in the mesenteric lymph glands and transferred hence to blood capillaries, so gradually as not to be conspicuous in analyses of the portal blood.

For practical purposes, therefore, and disregarding minor exceptions, it may be concluded that (post-absorptive) chyle is ordinary lymph plus absorbed fat and that the greater part, if not practically all of the fat absorbed, passes to the systemic blood circulation through the lacteals and thoracic duct. Furthermore, as was established by Asellius, chyle exists in the lacteals, and the lacteals merit their name only during the period of active absorption from intestinal contents when the latter actually contain fat.

It is extremely probable also, that the lymph of other parts of the body becomes practically identical with chyle, after inunction, hypodermatic and intracellular (tissue) injections, fracture of long bones involving the medulla, and in conditions involving the absorption of exudates or lesions in which fatty changes have occurred. Gabler and Quevenne found as high as 0.92 per cent. of fat in the contents of a lymphatic fistula of a woman's leg, whereas Munk and Rosenstein found as low as 0.04 per cent. of ether extract (a quarter or possibly half of which might consist of other than true fat) in the contents of a human thoracic duct fistula.

As to the actual proportions of fat that may be present in chyle, the latter investigators obtained results from 0.04 to 6.5 per cent. of ether extract in the contents of the thoracic duct, while the maximum fat content was obtained experimentally by Zawilski after feeding animals on pure fat—14.6 per cent.

Pathology.—Practically nothing is known as to functional variations in the chylophoric apparatus nor as to definite pathological lesions, except as the lacteals, glands, and afferent trunks are involved in ordinary gross lesions and traumatisms, of which the only intrinsic lesion is lymphadenoma and, theoretically, lymphangioma. The last is, however, not recorded except in the form of enlargement of vessels due to obstruction.

Ultimate Disposition of Chyle.—As has already been mentioned, it is somewhat doubtful whether digested carbohydrate or protein is actually absorbed, as part of the nutritive process, into the lacteals, although certain analyses suggest that the lymphatic chyle varies in its content of these substances as well as of fat, corresponding to periods of active digestion and absorption, so that the protein and carbohydrate of chyle are not merely the residual amounts common to the body fluids generally. Nothing is definitely known as to this point, and it is not worth while to discuss the various theories and opinions as to the exact method of absorption of protein and carbohydrate, particularly the reconversion at some point of cleavage products of protein digestion into albumin.

An analogous reconversion, however, occurs in the case of fats which, though digested in the intestine into glycerin and fatty acids, occur even in the central lacteal of the villus, as neutral fats again. The fatty acids have, meantime, been rendered soluble either by combining with alkaline carbonates to form soaps of sodium and potassium with liberation of carbon dioxide and water, or by some solvent action of the biliary salts of glycocholic and taurocholic acids which latter certainly expedite the absorption of fats. Staining methods even show fats as such near the bases of the columnar cells of the villi so that it has been assumed that a reconverting lipase is secreted by these cells.

At any rate, for practical purposes, it may be stated that the great majority of the fat absorbed from the intestinal chyle, passes into the intestinal lymphatics and that, even at their origin in the villi, it is in almost its original form; that it does not undergo any detectable modification even by the mesenteric lymphatics nor in its slow course through the affluents of the thoracic duct; that it is discharged into the general blood stream through the left innominate vein; that, even in the blood, it retains its original specific characteristics, at least to a large degree, and that, in rabbit fat-feeding experiments, characteristic exogenous fat may even be deposited in the cellular tissues. However, under normal conditions, each animal tends to establish a characteristic fat of its own, though doubtless not so much by virtue of intrinsic metabolic peculiarities as on account of habits of eating which determine an average characteristic intake. Fat globules are still discernible in the blood stream for some time after the absorption of a fatty meal but gradually disappear, from adsorption to proteins. In the deposit of fat, it is probable that a recleavage and return to neutral fat occurs. Fat may also be deposited on a fat-free diet, unquestionably from carbohydrates, perhaps also from proteins, though the exact process of chemical change is not known.

There seems to be no doubt that the oxidation of fat occurs under the stimulus of some ferment or ferments, though the nature of the ferment and its origin are unknown, beyond the clinical observation that failure of oxidation and undue accumulation of fat accompany thyroid atrophy and depression of function and also occur after removal or atrophy of the ovaries or

testicles, respectively. So, too, the glycolytic failure of diabetes is accompanied in many instances by a relative failure of the putative fat-oxidizing ferment although, in such cases, the fat ration is usually increased beyond the normal to compensate for the restriction of carbohydrates and there may even be an absolute increase of fat oxidation as evinced by the consumption of previously stored fat.

Fat oxidation terminates in the production of carbon dioxide and water. The intermediate processes are not known but it is assumed that they involve the glycerin and fatty acid radicles independently and that the latter are successively broken down from palmitic, stearic, and oleic acid radicles, the components of ordinary food fats, into oxybutyric acid, diacetic acid, and acetone, from the fact that these substances tend to appear in the excretions, notably the breath for acetone and the urine for all three, in reverse order, corresponding to the severity of diabetes or some other acid intoxication apparently due to interference with the normal catabolism of fats. This interference with fat catabolism is prevented by the oxidation of carbohydrates, provided they are ingested and the body is capable of catabolizing the resulting sugar to the amount of 80 grams or more a day. It has been assumed by some and is not yet absolutely disproved that these substances arise from the faulty catabolism of proteins but it is probable that they arise solely from fats.

It may be noted in passing that the deposit of fats may occur readily if merely fatty acids are administered, glycerin apparently being formed by the elimination of the $NH_2$ radicle from alanin which, in turn, is derived from certain amino acids of protein. On the other hand, the observation that fat may be deposited from a diet lacking not only fats as such but fatty acids, in connection with the common clinical and veterinary observation that starches act as a "fattening food," suggests that both the fatty acid group and the glycerin radicle may be derived from carbohydrates alone. A. L. Benedict.

**Chylous Accumulations.**—Pathological accumulations of chylous or pseudochylous matter, may be classified as follows, the first two subdivisions being included for the sake of convenience only.

1. Fatty accumulations due to local degenerations, though not necessarily due to local causes nor limited to any one place. Here may be mentioned fatty infiltration and metamorphosis, caseous and saponaceous degeneration of exudates, fat necrosis, etc. Cancerous, tuberculous, and endotheliomatous disease of serous surfaces, old sterile accumulations of pus, and caseous degenerations of lymph nodes connected with the lacteal apparatus, where some leakage of true chyle may occur, are especially apt to imitate genuine chylous accumulations.

The differentiation between chylous and pseudochylous accumulations must depend more upon a study of the antecedent lesions and circumstances than upon absolute chemical and microscopical demonstration and is often impossible. The following points of differentiation are adapted from L. Napoleon Boston's discussion of chylous ascites in the *Journal of the Am. Med. Assn.*, Feb. 18, 1905.

True chylous accumulations consist of a fine, permanent emulsion, with few cellular elements, whereas pseudochylous accumulations are less perfectly emulsified, tend to form a sediment and a supernatant ring of oil on standing, contain larger fat drops, and granular debris, with epithelial cells, polymorphonuclear and eosinophile leucocytes. But Congdon's case studied by the writer, showed a distinct supernatant ring of oil, though undoubtedly genuinely chylous, and oil has been reported in other cases of long duration, even in connection with other loculi containing typical chyle. So, too, secondary changes, as separation of fatty acids, soaps, calcareous nodules, hemorrhage, and inflammatory lesions, have been noted in genuine chylous accumulations of long standing.

True chyle accumulates rapidly after tapping, whereas pseudochylous accumulations reform slowly. But several cases of chylous accumulation have been cured by tapping alone; in other words, the leakage of chyle is not necessarily permanent.

Senator has been repeatedly quoted as saying that sugar is invariably present in chylous accumulations. Sugar is usually lacking in pseudochylous accumulations and present in true chyle, but exceptions have been actually observed in both directions. What Senator really said was that, excluding diabetic cases (in which either form of accumulation would contain sugar), the presence of sugar is rather characteristic of the true chylous form.

The melting-point, odor, and various chemical characteristics of fats ingested should theoretically be reproduced in true chylous accumulations, Strauss having obtained butter fat from a case with two fistulæ, Senator similar results from the intermittent administration of olive oil, whereas degenerational fat collections are not influenced by the food. But, as some chylous accumulations, especially mesenteric cysts, date back many years, it is obviously impossible to lay any stress on the differential analysis of fats except in cases of recent accumulation when the diet has lacked the variety of fatty foods likely to have been taken. For instance, in the case studied by the writer, there was a distinct odor of mutton fat but the patient denied having eaten any though, as the case dated back some months at least, and probably several years, this history could not be relied upon. Even abscesses may have a fecal odor or that of certain foods, and the same may be true of degenerative collections of fat.

The amount of fat in the chyle is said to be in direct relation to the amount ingested, whereas pseudochylous accumulations are not affected by the diet. The very considerable variations in fat percentage in chyle, from hour to hour, in relation to the considerable duration of a chylous accumulation, negative the truth of this assertion.

2. Collections of fatty matter absorbed from other sources than the intestine. While fat carried by the lymphatics from any source is closely analogous to true chyle, the location and history of inunction, injection, or other local source of fat, is usually easily sufficient for a differential diagnosis. Lipuria, due to obesity, to large doses of cod-liver oil, etc., to fractures of long bones involving the medulla, is about the only instance in which a confusion may occur, and then mainly because of the question, not of the ultimate source of the fat, but of the route by which it reaches the bladder.

3. True chylous accumulations are due to leakage from the lacteals or other lymphatic channels to which they are tributary, either in the direct course of the lymph current or by anastomosis. Such accumulations grade imperceptibly into accumulations of clear lymph. Apparently, even when fluid is due to filtration from the lacteals, it does not have the consistence of chyle unless there is an actual rupture of a chyle-bearing lymphatic, though not necessarily macroscopic nor permanent. Thus, with an essentially identical obstructive lesion, as at the receptaculum chyli, one case may develop a chylous cyst or ascites, another a lymphatic accumulation; or both forms may be present in the same case.

The possible varieties of true chylous accumulations, according to anatomical location, are as follows:

1. Mesenteric cysts, with which may be included accumulations within the peritoneal investment of the intestine (of which only one case is recorded, the location being opposite the mesenteric attachment),

retroperitoneal cysts, and those in which the gross anatomical limits of the lacteals have been exceeded, perhaps by spontaneous dissection, perhaps by the leakage of an adjacent, anastomotic lymphatic. Friend and the writer have collected, independently, about 100 cases of this kind which are tabulated in *Surgery, Gynecology, and Obstetrics*, of July, 1912, and June, 1913, dating from 1699 to the present. These cysts are of various sizes, from that of a pinhead in a few cases of multiple involvement seen in the first stages, up to that of enormous collections filling all the available space in the abdominal cavity and a hernia. They may be single, multiple, or multilocular and may present every conceivable variety of association with lymph, hemorrhagic collections, and late changes with absorption of everything but oil, saponaceous and calcareous degeneration, etc. None of this series has been shown to be filarial and in only a few has any definite lesion of the lacteal vessels, receptaculum, or thoracic duct been demonstrated, so that the ordinary etiology is probably a traumatism of minor degree, or temporary obstruction due to intestinal distention, perhaps against some normal line of resistance or a peritoneal band. The history and appearances also show that in many cases there must have been a spontaneous healing of the ruptured vessel with no further leakage and even resorptive and secondary chemical changes in the original accumulation.

2. Chylous Ascites.—L. Napoleon Boston (*loc. cit.*) tabulated one hundred and twenty-eight cases, though some were probably pseudochylous and due to tuberculous or cancerous degeneration. Arthur R. Edwards (2d edition of this work) collected one hundred and fifty-five cases of adipose (chyliform or pseudochylous) and genuine chylous acites. Only three of Boston's cases were filarial. In only eleven was there demonstrated to be obstruction of the thoracic duct and in only seven was the duct or the receptaculum chyli ruptured. Otherwise, the point of leakage was not determined. Four of these were in combination with mesenteric cyst (all four cases in young children). Chylous fluid has been found in the peritoneal cavity in several cases of the series of mesenteric cyst, in addition to these four, and in one case of multiple, thin-walled cysts, in which the receptaculum and first part of the thoracic duct were obliterated, the cysts were ruptured at the merest touch (Wenning's case). Thus, it is likely that many cases of chylous ascites, especially those with no tendency to reaccumulation, and with no demonstrable lymph trunk obstruction, originate as chylous cyst of the mesentery and rupture into the peritoneum after the leak in the lacteal has closed.

3. Chylocystocele.—Six cases are mentioned in the first edition of this work and the writer has encountered no recent reports. The embryologic origin of the tunica vaginalis suggests that these cases are merely a variety of chylous ascites with gravitation through an open canal. But none of the case reports note this condition and there is no report of reaccumulation, as chylous ascites, following operation. In several instances, the spermatic lymphatics are distinctly stated to have been distended with milky fluid. Hence chylocystocele is probably of local origin, due to rupture of the spermatic lymphatics, the presence of chyle being due to intimate anastomosis with the lacteals from the small intestine—or it may be that there is a local absorption of fatty matters and extractives from the semen, so that such accumulations are not strictly chylous.

4. Chylothorax.—Busey, in the first edition of this work in 1888, collected ten cases; Frank A. Baldwin, in the second edition, forty-seven, beside fifteen pseudochylous or doubtful ones. There have been a few recent cases. The ages vary from two to upward of sixty; distributed as follows: under 10, 2; 11 to 20, 8; 31 to 40, 7; 41 to 50, 8; 51 to 60, 3; over 60, 2; total, 30. There were thirty-one males out of a total of forty-one in which sex was mentioned. With regard to etiology: traumatic cases, 16; pressure by growths or tuberculous lymph nodes on the duct, 9; secondary growths in the duct, 9; thrombosis of left subclavian vein, 4; proliferating lymphangitis, 2; aneurysmal dilatations of duct, 2; thrombosis of duct, traumatic obstruction or thrombosis after operation for carcinomatous nodes of neck, obstruction of radicles of duct from inflammatory thickening of mesentery, mitral disease, filariasis, each one, 5; total 47. Seventeen of these forty-seven cases were complicated with chylous ascites and Bayer collected twenty such cases altogether. Such cases are explained as due to obstruction of the duct high enough to allow escape into both peritoneal and thoracic cavities or to a lymphatic communication through the diaphragm, none to a frank opening. Simon reports a case in which a lymphangioma of the leg extended upward and ruptured into the pleural cavity. One case of chylothorax was accompanied by chylopericardium, one by chyluria, and one by "milky diarrhea," whose direct connection with chylothorax is doubtful.

The *diagnosis* of chylothorax depends upon three factors: (1) Physical methods of examination, perhaps to include radiographic examination, to demonstrate fluid in one or both pleural cavities; (2) Significant history as of traumatism, new growth, liability of obstruction; (3) Inspection and chemical and microscopical examination of fluid, as already mentioned, to differentiate between genuine chylous and pseudochylous or other kinds of fluid.

5. Chylopericardium has been observed in only a few cases and probably some of these were pseudochylous, due to local fatty degeneration of exudates. In true chylopericardium, the obstruction must be at or near the mouth of the major thoracic duct. Arthur R. Edwards (2d edition of this work) found only two indubitable cases, one of these being complicated with chylothorax with leakage from the pleura, the other being due to local rupture of lymphatics. Hasebroeck's analysis of the fluid was as follows: albumin seven per cent., cholesterin 0.3 per cent., lecithin 0.1 per cent., fat one per cent., alcoholic extractives 0.2 per cent., aqueous extractives 0.2 per cent., salts 0.9 per cent. Virchow has reported the case of a newborn calf, in which thrombosis of the external jugular vein led to surcharging of the lymphatics of the entire system tributary to the major thoracic duct, the heart and the intestine as well as other viscera being marked by distended lymphatics. This case was not chylous but undoubtedly would have become so if the animal had survived so as to take milk.

6. Chyluria (*q.v.*).—This must be sharply distinguished from lipuria due to surcharging of blood and lymph with fat from obesity, large ingestion of cod-liver oil, fracture of long bones, etc. The cases of true chyluria are mainly filarial and hence are reported mostly from the tropics but other cases are not of this nature and are probably analogous to obstruction of lymphatics in other regions, the chylous nature of the fluid depending on anastomosis with lacteals.

Prognosis.—Chylous accumulations are unirritating and are not prone to bacterial decomposition while, mechanically, they produce no more disturbance than serous accumulations of the same amount and location, nor are they so apt to enlarge rapidly. As chyle contains no mineral matter not derived from the bodily fluids generally and no notable amounts of organic nutrients other than fat which is easily formed by the body from either carbohydrate or protein, the abnormal accumulation produces no significant deprivation. Even the interference with

the lymphatic circulation is not usually a matter of great moment except when it involves the major thoracic duct and, even then, life may persist for years unless the obstruction is located at or near the confluence with the vascular circulation. Hence, generally speaking, the prognosis *quoad vitam* becomes grave only for cases of chylopericardium or for accumulations involving more than one cavity, or on account of the nature of the underlying cause. It is probable that practically all cases of chylopericardium will prove fatal although the extreme rarity of the condition renders such a prediction liable to revision as experience accumulates, especially with the modern improvements in thoracic surgery. About eighty to ninety per cent. of cases of chylothorax are fatal, this percentage corresponding to the proportion due to malignant disease, to obstruction at the terminus of the thoracic duct and to extensive crushing or penetrating traumatisms. Excluding those cases of chylous ascites secondary to the rupture of mesenteric cyst, the gross mortality is nearly as high, although some of the fatal cases had persisted for many years. Excepting that extensive traumatisms are more apt to affect the thoracic duct high enough to produce chylothorax, it is obvious that chylous ascite involves practically the same factors with regard to underlying cause and to degree of interference with lymph drainage as does chylothorax. When, however, the chylous ascites is due to rupture of a tributary to the receptaculum, even of considerable size, the prognosis is relatively much more favorable. The results in chylocele have been very favorable. Chyluria, being often with difficulty distinguished from lipuria, and being sometimes filarial and sometimes due to various other causes of lymphatic obstruction, it is impossible to speak in general terms as to the prognosis, except to say that the condition is always serious and that the result must depend upon underlying factors.

Of the series of ninety-six cases of chylous cyst of the mesentery, or analogous subperitoneal or retroperitoneal structures, collected by the writer (including a few of Friend's series), sixty recovered, fourteen died after operation, twelve were diagnosed or at least verified at necropsy, though several after the condition had persisted for many years, and ten results were not stated. The mortality appears, therefore, to be about twenty-five per cent. However, the age incidence at the time of diagnosis or of ultimate verification suggests that many cases may have existed for a long term of years and that the actual statistics of death exaggerate the fatality. Thus, there were five cases under 1 year; 6 from 1 to 5 years; 9 from 6 to 10 years; 4 from 11 to 15 years; 7 from 15 to 20 years; 15 from 21 to 30 years; 12 from 31 to 40 years; 6 from 41 to 50 years; 8 from 51 to 60 years; 3 from 61 to 70 years; 4 from 71 to 80 years; 8 not stated except that 1 was in a young adult and 1 in a child.

Treatment.—While many of the earlier cases gave surprisingly few symptoms during life and were discovered only at necropsy, or were under observation and occasional treatment of intercurrent affections and suffered only mechanically from the presence of a cyst or ascites, death being due to some intercurrent cause or the gradual undermining of health, at present it may be considered that treatment is distinctly surgical. This term, however, includes pre- and postoperative care, the attendance upon cases obviously hopeless, the expectant treatment of gross traumatisms, as of the thorax, and, perhaps most important of all, at least from the standpoint of advancing our knowledge of these conditions, diagnosis.

General principles must be followed in regard to the relief of discomfort, support of the circulation, etc. It is very doubtful whether any medical treatment of a resorptive nature will prove efficient although, in cases not manifesting emergent symptoms or those obviously hopeless, it is justifiable to employ iodides cautiously, Credé ointment to stimulate leucocytosis, etc. Most writers on the subject have emphasized, on the one hand, that fats should be withheld from the diet, and, on the other, that the accumulations should not be tapped on account of withdrawing this source of nourishment which might otherwise be absorbed and utilized. The latter dictum obviously applies rather to the larger cavities and especially to the peritoneum. But it should be borne in mind that some of the early cases lived for years with occasional tappings and it is questionable whether the dicta regarding fats are practical. In a suspected or demonstrated case, every opportunity should be given to the clinician, chemist, and chemical pathologist to study the physical signs, the fluid, and the course of the case.

So far as the pericardium and the pleuræ are concerned, anything in the nature of surgical treatment depends upon the ordinary principles of management of extensive traumatisms, expectant treatment of hopeless cases, or of those in which radical operation is out of the question, and upon the development of a radical technique for intrathoracic conditions, the successful achievement of which will probably depend in turn upon some device for maintaining proper pressure during extensive operations.

Chylocele cases will probably be treated as ordinary cystocele until the nature of the fluid is apparent, when the operation will include the extirpation of dilated lymphatics, and the removal of any growth that may be encountered.

Chyluria, more often than other forms, will prove to be of filarial origin and hence will have a more or less specific treatment.

In several cases of ascites the patients have recovered or have lived in comparative comfort, under treatment by tapping. Here must be considered the differential diagnosis between true and false chylous ascites. It is probable that a case due to rupture of a lymphatic vessel of comparatively small size, with subsequent spontaneous repair of the rupture, would recover equally well without tapping, the chylous discharge being resorbed. On the other hand, it is questionable whether a case with persistent leakage would or would not be amenable to the theoretic treatment by celiotomy, search for, and ligation of the vessel. Cases in which the ascites is due to leakage from a cyst offer more favorable conditions for operation, as will be discussed later. If the differential diagnosis could be made in advance between ascites due to rupture of a tributary lymphatic vessel and that due to some lesion involving the receptaculum or thoracic duct, a freer choice of route of operation would be allowable according to circumstances. Usually, however, as the operation is exploratory, even if the general correct diagnosis has been made by preliminary tapping, the abdominal route will be taken and the details and extent of the operation must depend upon the lesions found and the possibilities of the case. If the ascites is due to obstruction at or beyond the receptaculum, the outcome will usually prove unfavorable, either because of the presence of a malignant tumor or because of the mechanical impossibility of restoring the integrity of the receptaculum and duct. However, in favorable cases, external pressure may be relieved.

Mesenteric, subperitoneal, and retroperitoneal cysts have been treated as follows: aspiration (mostly early cases), 5; drainage, sometimes after preliminary incision, as under the impression that there was a purulent accumulation, tuberculous peritonitis, etc., or as the method suggesting itself in an unforseen or unheard of condition, sometimes after spontaneous rupture producing a chylous ascites, 24; some form of enucleation or resection, 31; enucleation in two stages—marsupialization, 4. In several cases,

the nature of the operation is vaguely stated. In a few instances, the cyst seems to have been ignored after being found and in practically all cases of multiple small cysts, accompaning one or a few large ones, the small ones were either ignored or merely ruptured. While all the marsupialized cases recovered, it does not appear that the operation in two stages is necessary unless occasionally on account of the general condition of the patient. So far as can be judged, the deaths after enucleation or extirpation were due to primitive methods, intestinal strangulation, peritonitis, or general debility; and, while it is impossible to lay down any law to govern all cases, some form of extirpation of any large and thick-walled cyst, rupture of small, thin-walled cysts, and ignoring of numerous, minute cysts, seems to be the operation of choice, primary closure or drainage to be determined by circumstances, and marsupialization, with ultimate resection, to be reserved for cases in which speed is essential or in which peculiar mechanical conditions are encountered. Barring moribund, septic, and complicated cases, modern surgery should afford a cure in at least seventy-five per cent. of cases. Considerably better results will probably be achieved, the main factor at present to be considered being the mere familiarizing of operators with the existence and nature of such cases and the results and methods already determined by a widely scattered experience.

A. L. Benedict.

**Chyluria.**—Definition and Etiology.—Chyluria signifies the presence of chyle, and consequently of fat in a state of emulsion, and albumin in the urine. Sugar, a constant ingredient of chyle, is so rarely found in chyluric urine that its presence would warrant the suspicion of coincident diabetes mellitus.

There are two varieties of chyluria, the parasitic and the non-parasitic, the former being by far the more common. It has been customary to speak of these two forms as "tropical" and "non-tropical," but since the demonstration of parasitic chyluria in temperate zones this division is no longer appropriate. It is nevertheless true that in the vast majority of cases of parasitic chyluria the patients have become infected in tropical or subtropical countries. Data regarding the etiological influence of age, sex, and occupation are either scanty or absent entirely. According to Senator, chyluria has not been observed in childhood or in the aged. There is, however, no reason, in the nature of things, why it should not occur at any period of life, for its cause is mechanical obstruction of the thoracic duct and this may be seated within the caliber of that tube, in its walls, or outside of it.

Much the most common cause of chyluria is obstruction of the thoracic duct either by adult or embryonic forms of the *Filaria sanguinis hominis nocturna*. In the great majority of cases of chyluria, embryonic filariæ may be readily detected in a drop of blood from any part of the surface of the body, provided the blood be obtained at night. During the day, the embryos of filaria nocturna are very scantily present in the surface capillaries or are absent from them altogether. Manson, observing the embryonic characters of the circulating filariæ and their presence in the surface capillaries chiefly or solely during the night, came to the conclusion that they must reach a further stage of development outside of the body in the interior of some nocturnal blood-sucking animal. He exposed a patient with "filariasis" to the bites of mosquitos, and found the embryos in the bodies of these insects, in which, in the course of from five to seven days, they attained a length of one-fifteenth of an inch. In the blood of man they measure from one-seventieth to one-eightieth of an inch, and are enclosed in a sheath from which they make their escape in the viscid blood of the mosquito. The mosquitos with the embryonic filariæ in their interior seek water in which to deposit their eggs. This function accomplished, they perish; the embryonic filariæ are liberated, and through the medium of the water in which they exist, gain access to the human system. Manson's latest researches have practically demonstrated that the filaria may be transmitted directly from the infected to the non-infected by the agency of the mosquito (*Culex ciliaris* or *C. pipiens*) in the same manner as the *Hematozoon malariæ* is transmitted by Anopheles. Two or more of the ingested parasites attain maturity in the lymphatic system and continue for an indefinite period (sometimes for many years) to produce swarms of embryos. The presence of filaria embryos in the blood does not necessarily give rise to disease, their transverse diameter ($\frac{1}{85\,0\,0}$ inch) being, as a rule, such as to enable them to traverse the narrowest channels of the blood and lymph. Occasionally, however, they occlude these vessels, and this is believed by Manson to be due to the fact that the embryos are prematurely born enclosed in a sac or sheath of globular form, the transverse diameter of which is about $\frac{1}{70\,0}$ inch. Disease in man occasioned by the filaria is therefore the result of disease in the filaria itself. If the adult female filaria produces the young in a physiological manner they are innocuous to their host; if, through disease or irritation, she brings them forth prematurely, they obstruct the lymph channels and cause one or more of the diseases grouped under the title of "*filariasis*."

The principal diseases to which the filaria gives rise are abscesses, lymphangitis, dermatitis and cellulitis, erysipelas, orchitis, chyluria, chylous dropsy of the peritoneum, chylous dropsy of the tunica vaginalis, varicose groin glands, lymph scrotum, and elephantiasis. Chyluria is not common even in those countries in which filariasis prevails.

As above stated, obstruction of the thoracic duct from any cause may give rise to chyluria. As stated by Manson, the "cause of chyluria is obstruction of the thoracic duct, and this may be brought about in any climate by pressure on the duct, by tumors, by infarcts, by growths, etc.; but in the form of chyluria endemic in the tropics . . . . . the cause of the obstruction is the parent *Filaria nocturna*."

A case reported by Mr. Leigh Hunt in which transient chyluria was produced by traumatism, a fall upon a pile of stones.

Symptoms and Signs.—The onset of chyluria may be preceded by no symptoms whatever. In some cases, however, there is a sense of discomfort or pain in the lumbar region or the groins, the perineum or testes, before the chylous urine appears. The first symptom may be retention of urine due to the intravesical formation of coagula which occlude the neck of the bladder or the urethra.

In the great majority of cases chyluria is intermittent, being dependent, for example, upon posture, digestion, bodily exertion, etc. In one of my cases it first appeared during the expulsive pains of labor, gradually ceased after parturition, and did not return until about two years later at the birth of another child. The influence of posture is shown by the fact that in some cases the nocturnal urine is chylous while that of the day has a normal appearance. The general health is, as a rule, well maintained, although if the discharge of chyle is long continued, emaciation, anemia, and great debility set in and the patient dies from exhaustion.

The appearance of chylous urine is highly characteristic. On careless inspection it might readily be mistaken for milk, but when examined more closely it will usually be found to contain coagula of a delicate pinkish tinge or more deeply colored like ordinary blood clots. The gross appearances, in a case of my own, are thus described: "The urine, after standing for several hours in a narrow cylindrical vessel, separates into two portions, of which the lower is distinctly

hemorrhagic: while the upper has the appearance of milk or cream. Floating on the upper chylous layer are numerous coagula of a delicate, pinkish hue, and almost translucent, while at the bottom are a few small blood clots" (*Medical News*, May 2, 1896). In some cases, after standing for a short time, the entire mass of the urine coagulates so as to resemble *blanc-mange*.

Diagnosis.—There is no difficulty whatever in making the diagnosis of chyluria. Lipuria, which signifies literally the presence of fat in the urine, should never be confounded with it. In chyluria the fat is in the form of an emulsion so fine as to require the strongest objectives to resolve the droplets of fat. In lipuria, on the other hand, fat globules are seen with comparatively low powers, either free or enclosed in cells or tube casts. It is very seldom that lipuria exists in such degree as to alter the macroscopic appearance of the urine, while in chyluria it commonly resembles milk. The presence of clots is also diagnostic of chyluria. The fat may be separated from chylous urine by shaking it up with ether. The ether, with the dissolved fat, rises to the surface and is then decanted. On its evaporation the fat is deposited. The urine from which the fat has been thus extracted and consequently rendered more or less transparent may now be tested for albumin, which is constantly present in greater or less degree. In addition, chylous urine contains cholesterin and lecithin, and among the albuminous bodies, in addition to serum albumin, it contains fibrinogen, hemialbumose or propeptone, and peptone. It is stated positively by Senator that chylous urine does not contain sugar. This remarkable fact—namely, the absence from chylous urine of a constant ingredient of chyle—has given rise to the opinion that chyluria is not caused by a direct admixture of chyle with the urine. In the opinion of the writer this view is absolutely refuted by the post-mortem appearances observed in cases of fatal chyluria. These consist, for the most part, of a state of varicosity of the lymphatics in immediate relation with the urinary tract. In a case of my own," the lymphatic vessels, especially those of both renal pelves, were enormously dilated and convoluted, many of them being of the caliber of an ordinary lead pencil. The dilatation was most marked on the right side, and in the pelvis of the corresponding kidney there was a pale lymph clot similar to the coagula passed with the urine during life" (*loc. cit.*). In this case the communication between lymphatic and urinary tracts was practically demonstrated. It is possible that the absence of sugar from chylous urine may be due to the presence of some as yet unrecognized glycolytic ferment in the renal secretion.

In all cases of chyluria both the blood and the urine should be examined for the filaria. In the former there is little difficulty in finding it provided the blood be withdrawn (by needle puncture of finger or ear) during the night. In the urine the parasite is apt to escape detection because it is frequently enclosed in coagula. These should therefore be broken up with a glass rod and the urine allowed to stand in a conical glass, at the bottom of which the liberated filariæ may be found.

Prognosis.—The prognosis of chyluria is not unfavorable, but depends largely upon the mode of life of the patient. Manual labor and severe physical exertion of any kind tend both to develop and to perpetuate the disease. In women the pregnant condition is a serious complication.

Treatment.—With a view to prophylaxis a sedentary occupation should be recommended in preference to one demanding physical exertion, and with the same object in view, straining at stool should be avoided by the occasional use of laxatives. As long as the urine is chylous, the strength should be maintained by nutritious food, tonics, and [illegible] kept at rest. It is doubtful whether any among the numerous remedies employed in chyluria are of the slightest direct benefit. With a view to their supposed efficacy in checking the discharge, astringent preparations of iron, gallic acid in large doses, and various vegetable decoctions containing tannin have been administered. In the parasitic form of the disease attempts have been made to destroy the filaria with thymol and other vermicides, none of which, in the opinion of the writer, has the slightest effect in this direction. I have elsewhere discussed the treatment of filariasis, and will therefore confine myself to the statement that there is no drug that will kill either the adult filaria or its embryos while they circulate in the blood, and that even if such a drug were known it would be wisest to refrain from its employment. When the adult filaria has its seat in one of the extremities and dies, an abscess usually results; or it is perhaps more correct to say that adult filariæ have been found in such abscesses, the presumption being that the latter are caused by the former. If, however, the adult filaria should die in the thoracic duct, with consequent abscess, the result would be of necessity fatal.

Frederick P. Henry.

**Chyme.**—"Food which has undergone gastric digestion and has not yet been acted upon by the biliary, pancreatic, and intestinal secretions" (Illustrated Dictionary of Medicine). The term chyme is, therefore, nearly synonymous with stomach or gastric contents but is less general in that it does not apply to jejune contents consisting of mucus, débris, and pure gastric juice, and more general in that it includes [illegible] up to the time at which intestinal digestion becomes established, with change of reaction from acid to alkaline. This point of time and the corresponding place in the intestine are, obviously, variable but as the extrusion of stomach contents through the pylorus begins, at least for liquids and soft semi-liquid matters, within a few minutes after ingestion and continues rhythmically at intervals of a few minutes until the stomach is empty and as the joint secretion of the pancreas and liver is discharged through the papilla of Vater very promptly as a reflex, chyme may usually be considered to have passed the point of becoming intestinal chyle as soon as it reaches the lower part of the descending portion of the duodenum. There is also a period of a few minutes after deglutition, before any appreciable digestive action, beyond salivary digestion, occurs in the ingesta and it has been shown that the gastric juice penetrates to the center of the gastric contents gradually. Thus, it probably often happens that ingesta reach the beginning of intestinal digestion in the duodenum, without ever having conformed to the technical definition of "chyme."

As gastric secretion varies widely, even within physiological limits, and as the action of gastric juice obviously depends also to a large degree upon the bulk, nature, and consistence of the gastric contents; and as, moreover, the degree to which the contents are actually digested differs according to the time at which they are examined, the situation with reference to the secreting surface of any particular particle or mass of stomach contents, and as various portions of the ingesta remain in the stomach for very variable periods, it is impossible to discuss chyme in any technical sense, except by reference to a great many details which will be considered under other titles.

The following general approximate statements may, however, be made as a matter of convenience.

Dense fibrous tissues, either animal or vegetable, while usually stimulating the secretion of gastric juice, are not themselves digested in the stomach. The same applies even to strictly digestible starch

and protein, incased in indigestible coverings or in masses too large for penetration of gastric juice. Carbohydrate digestion in the stomach is practically limited to cooked starch, although small amounts of raw starch are probably also converted. Such digestion depends entirely upon ptyalin, hence mainly upon the perfection of mastication and insalivation, but also upon the fact that ptyalin digestion is inhibited by a degree of hydrochloric acidity amounting to about fifteen degrees decinormal, so that it is confined to the first quarter or half hour after ingestion. Not to consider pathological conditions of subacidity and sluggish motility, with little fermentation and careful habits of mastication, in which nearly all of the starch may be digested in the stomach if only moderate amounts (say 50 to 100 grams) are taken at a meal, the degree of carbohydrate digestion obviously varies greatly in normal individuals, and even with hasty and imperfect mastication and hyperchlorhydria without ischochymia, probably at least five to fifteen grams of starch are digested into sugar, before the establishment of sufficient acidity to inhibit the action of ptyalin. This digestion consists in the hydrolysis of starch, through polymerization stages of dextrin, into maltose, isomeric with saccharose and lactose, having the formula $C_{12}H_{22}O_{11}$. Its further conversion into dextrose, $C_6H_{12}O_6$, occurs mainly through the action of the intestinal invertase, but there seems to be a slight degree of similar conversion in the stomach, due either to ptyalin or to a special gastric ferment or, perhaps, to penetration of traces of intestinal invertase into the cavity of the stomach. Some experiments also point toward a slight digestive action on raw starch and even cane sugar, along similar lines.

Slight cleavage of fats occurs in the stomach, perhaps due to accidental organized ferments, to penetration of steapsin from the pancreas, or to a direct gastric secretion. However, such digestion never reaches amounts practically considerable.

Proteolysis occurs by the joint action of pepsin and hydrochloric acid, through the stages of acid albumin and albumoses into the stage of true peptones. Recent experiments show that further cleavage into amino bodies also occurs even in the stomach.

The coagulation of milk may be mentioned under the head of gastric digestion. It does not appear that any analogous coagulation takes place in the stomach and it is not entirely beyond question that the coagulating ferment, rennin, is distinct from pepsin. Normally, the two ferments or the two functions of the one ferment coexist and, in the great majority of cases of achylia, both functions are lost coincidently. Discrepant statements by clinicians may be due to the fact that hypochylia, as in cancer, may produce a gastric juice so weak in ferments that even small particles of coagulated egg albumin are not appreciably digested while there is enough ferment, in conjunction with lactic acid, to produce more or less perfect coagulation of milk. The opposite condition may be due to the fact that certain samples of milk, undoubtedly due to some process of preparation, do not coagulate even with sufficient ferment activity to digest coagulated albumin.

As to the fate of chyme, it may be said that while probably minute amounts of various ingredients, including alcohol and various soluble medicaments, are absorbed through the gastric lining membrane, none of the normal ingesta or their digestion products are thus absorbed to any practical extent, not even water and salines. Thus the absorption of chyme takes place from the intestine, the degree to which it is subject to further digestion varying according to the nature of the particular ingredients, as already outlined.

Hence, so far as the stomach is concerned, the disposition of chyme after a varying degree of digestion, depends largely upon mechanical factors influencing its propulsion into the intestine. Thus, the older text-books contained very elaborate tables as to the time of digestion of various foods, meaning the time after ingestion at which the stomach was found empty. These tables are misleading by implying that this or that kind of meat or other viand, in given amounts, required definite periods of gastric digestion, in other words, that, after a definite duration of gastric digestion, the meal was propelled into the intestine practically at once. The following statements may be made in this connection:

The more watery and pultaceous a meal, and the fewer dense particles or masses it contains, and the less protein matter which both stimulates and requires gastric digestion, the more rapidly does it pass through the stomach. L. Duncan Bulkley claims that milk, given at body temperature, may pass through the stomach without calling forth secretion. At any rate, broths, and pultaceous cereal, fatty, and saccharine matter in amounts up to 200 c.c., may pass through the stomach within an hour. Ordinary test meals containing no large masses nor adhesive scales, consisting of bread stuffs, soups, eggs, finely divided meat, etc., with an aggregate total volume of 250 c.c. and containing solids up to fifty grams, are usually reduced by the end of an hour after ingestion to a total bulk of about 100 c.c., half or three-quarters of which is liquid (by centrifuge), the remainder consisting of moist solids. Judging by the acidity of the chyme, as compared with gastric juice, about half of the total bulk consists of ingesta and about half of gastric juice. Two hours after ingestion the stomach should be empty. In conditions of reduced hydrochloric-acid secretion, without pyloric obstruction, the same respective conditions are encountered in about half of these periods. On the other hand, hyperchlorhydria delays the exit of the meal by 50 to 100 per cent. and, in pyloric obstruction and gross failure of gastric motility, more or less delay up to complete stagnation may result.

After hearty mixed meals inclusive of vegetables consisting largely of cellulose, the one- and two-hour periods mentioned above are about doubled respectively. After very large meals, as banquets, six to ten hours may be taken for the normal period of complete emptying of the stomach. Hence, the rather approximate and not very stringent requirement that the wash water in the morning after a hearty dinner, should contain no food remnants if motility is normal.

Indigestible and adhesive materials like apple-core scales, oatmeal husks, certain hard gritty cereals, etc., may remain in the stomach to some extent for a day or more without indicating any true reduction of motility.

A. L. Benedict.

**Cibotium.**—*Penghawar-Djambi.* The hairy mass obtained from the rhizomes and stipes of *Cibotium djambianum* Hook, and some other large ferns of tropical Asia and Polynesia. Besides a very extensive use in mattress-stuffing and similar work, this substance has been considerably employed as a hemostatic. Although the juice of the rhizome is astringent and styptic, the cibotium appears to act in a purely mechanical way, like lint. In ordinary surgery we have many preferable agents, but these natural substitutes should be known to all army surgeons and others likely to require them in extreme cases.

Henry H. Rusby.

**Cicatrix.**—The new tissue formed in the healing of wounds, or during the process of repair of loss of substance by disease or injury, is a cicatrix. Otherwise stated, in incomplete regeneration the defect is filled with a new formation of connective tissue known commonly as a cicatrix or scar, or when occupying the interior of a deep-seated organ, a callosity.

Old cicatrices are usually whiter than the normal skin, but may be pink or bluish, and are often pig-

mented. Usually depressed, smooth, and glistening, they may be elevated, or, more rarely, on a level with the surrounding skin. Pigmentation is found especially in the cicatrices of chronic and syphilitic ulcers, or when pigments or particles of coal or gunpowder have been left embedded in the skin.

Once fully formed, cicatrices are a permanent part of the body, growing with its growth, so that, if they occur of a certain relative size in a child, this relation will be found to persist in the adult. Small cicatrices occasionally entirely disappear, but this never happens when the cicatricial tissue is at all abundant. Cicatrices are thus of great importance in establishing identity. They also frequently furnish reliable information of previous disease, as in the case of cicatrices following syphilitic lesions of the skin, suppurating bubo, or suppurating joint diseases.

The structure of cicatrices is the same in all parts of the body. When a wound of skin and subcutaneous connective tissue has just healed, the young cicatrix is redder, firmer, less pliable and yielding than the surrounding parts. Its shape and size depend chiefly on those of the original gap in the tissues which it fills. The new scar is composed of granulation tissue or embryonic connective tissue. Cicatricial tissue, however, differs from normal connective tissue, especially when new; eventually, from constant slow alteration, its structure closely approximates some of the normal connective tissues. The new tissue does not contain nor does it originate any other cells than those of embryonal connective tissue; nevertheless, sooner or later the tissues about it begin to proliferate upon or within the young scar. In this manner an epidermic pellicle soon forms upon its surface. The new cells, however, retain some of the plastic properties of those from which they were originally derived. Thus elastic fiber may eventually form in scars proper. Regenerative tissue in injuries of bone becomes ossified. When injured nerves regenerate, the nerve filaments of the divided ends penetrate into the scar tissue, and an analogous behavior is seen in connection with muscle fibers in injuries to muscles. Epithelial ingrowth into scars of mucosæ and viscera may lead to the formation therein of more or less abortive glandular tissue (tubular glands, ducts). True parenchymatous structures are said never to appear in scar tissue with the possible exception of scars of the salivary glands.

After this preliminary discussion of scars in general the text will be limited chiefly to cutaneous or external cicatrices. In most cases the epithelial cells have been derived from the rete Malpighii of the surrounding skin. During the process of cicatrization its cells form new nuclei, increase in size and number, and send out epidermal wandering cells. These wandering cells spread over the granulations of the wound, forming a delicate epithelial membrane that gradually diminishes in thickness toward the middle of the wound. This transparent, glistening pellicle can almost always be seen to spread inward on all sides from the edges of the wound. But it is sometimes observed to advance centrifugally from an "island" of epithelium in the midst of the wound. Beneath this pellicle, numerous small polygonal nucleated cells, separated by soft transparent or granular intercellular substance, are irregularly arranged in the meshes of embryonic blood-vessels. The cells are either white blood cells or connective-tissue cells. The blood-vessels are derived from those of the adjoining part by the channelling of protoplasmic sprouts. The tendency of this tissue is to develop into the white fibrous tissue found in old cicatrices. Many of the young cells are destroyed in this process; the rest become at first spindle-shaped, and finally acquire the characters of connective-tissue cells. The intercellular substance, at first not very abundant, becomes fibrillar and separates the remaining cells more widely. The whole cicatrix is now denser and drier than at first. Then the fibrillar intercellular substance contracts and condenses still further, the process terminating only when dense white fibrous tissue is formed. The contraction pulls on the neighboring parts, causing more or less wrinkling near the scar and drawing the adjacent tissues from their places. The blood-vessels also undergo changes. Many of them disappear entirely, and those which persist form a delicate anastomosing network of capillaries and small vessels communicating with those in the normal tissues on all sides of the cicatrix. The whole process is analogous to the development of embryonic tissue into adult connective tissue. In course of time, the cicatrix becomes loosened from its adhesions by the formation of adipose tissue beneath it. It becomes flexible, pliable, and easily movable, losing its adhesions to fasciæ and bone in many cases. Lymphatics and nerves also reappear, and in old cicatrices there are sometimes found a few elastic fibers. But cicatrices never originate hair, papillæ, sweat glands, or sebaceous follicles. When these are present they are either persistent remnants or else have grown into the scar at its periphery from the epidermal cells. Cicatrices of mucous membranes are similar to those of the skin. They are more apt to be the cause of serious trouble on account of the greater frequency of damaging contractions, producing strictures of the mucous tubes, as of the esophagus or urethra.

Cicatrices produce certain changes in adjoining parts of the body, and are liable to defects and diseases.

The amount of contraction depends on the quantity of new cicatricial tissue and the resistance of the neighboring parts. Since the scar is not as massive as the tissue it replaces, more or less depression must be the rule. Superficial scars may remain level with the skin, and in certain cases scars are hypertrophic and rise above the skin level. This is discussed later under *Keloid*. Wounds healed by first intention are followed by much less shrinking than when allowed to granulate and suppurate. The cicatrices of burns and scalds, wounds in the flexures of joints, and lacerated wounds usually produce the greatest deformities. The remarkable contractions that follow burns are due not to any peculiarities in the structure of the cicatrix, but to the great amount of new tissue and the facility with which the surrounding tissue yields. Slight contractions at the flexures of joints may seriously interfere with their functions and greatly impair the usefulness of the limb. In many cases disfiguring and disabling contractures follow burns and wounds treated with the utmost care. They are to be avoided only by securing, where possible, the primary union of the wound.

Weak cicatrices are frequently found when, during cicatrization, the granulations have been inflamed or pale and flabby. They are most common in the lower extremities and over the subcutaneous bones.

Cicatricial bands and masses may do serious damage when they contain or compress important vessels or nerves. Obstinate edema of parts supplied by the blood-vessels may follow. Impaired motion and sensation sometimes occur when nerve trunks are compressed by cicatricial tissue. The only remedy is to dissect out the flattened nerve from the dense cicatrix, hoping that it may be subject to less pressure in its new position. When nerves are divided and their ends are contained in cicatrices, beside the loss of motion and sensation the cicatrix is apt to be painful. The nerves are sometimes found to be bulbous, or the seat of fibrous degeneration. Here a portion of the nerve may be excised, or the ends dissected out of the cicatrix and sutured together.

Cicatrices also suffer from inflammation, wounds, contusions, and tumors.

Inflammation occurs in the same way as in other connective tissue. Abscess often occurs in recent

cicatrices as a result of retention of some foreign body, or of infection.

Wounds of cicatrices usually heal readily.

Cicatrices sometimes undergo degenerative changes, leading to the formation of elevated, scaly, itching nodules, called keloid. This is a fibrous or fibrocellular tumor, often of a pink color. It follows even slight cicatrices—for example, those of acne and chickenpox. It is more frequent, however, in cicatrices of burns and lacerated wounds.

Carcinoma of cicatrices may be either primary or secondary. Primary carcinoma is usually of the epithelioma variety. It occurs most commonly in cicatrices situated over bones, and following burns and gunshot wounds. It usually appears in cicatrices that have been much irritated or exposed to pressure and ulcerated, and presents no unusual phenomena.

Secondary carcinoma in cicatrices usually develops in three weeks or six months from the time of operation. It may appear in the cicatricial tissue, but usually in nodules in the subjacent or surrounding connective tissue.

Sarcoma is also found occasionally in cicatrices.

Treatment.—Until within comparatively few years the treatment of scars belonged entirely to plastic surgery. Recent innovations in medicine, however, have shown themselves of more or less value in reducing the deformity, disfigurement, functional disability and unpleasant subjective phenomena of cicatrices; while the rapid development of older therapeutic resources has also been of marked benefit in the same direction. Among the resources, old and new, which have recently been utilized in this field, are special techniques of massage, including vibration, the hot-air chest, Bier's, cups, hydrocarbon prothesis, decortication, injections of thiosinamine and fibrolysin, and the *x*-rays. However, the old classical procedures in the more severe type of scars—excision, often in successive steps, followed by skin grafting or transplantation, and aided when possible by the utilization of splints, weights, manual stretching, etc.—have not yet been superseded.

The modern treatment of cicatrices (including all preventive efforts) is decidedly a border-line subject and at present interests the general surgeon, the "cosmetic" surgeon, dermatologist, and physico-mechanical therapeutist (referring only to qualified and ethical practitioners). According to the point of view of each of these practitioners, the indications and modes of filling them naturally show differences, but on the whole the degree of harmony which obtains is conspicuous. The indications in the treatment of scars differ considerably with the locality. When the double viewpoint of cosmetic and functional restoration is considered, the most important regions involved are the face and throat, the hand and forearm, the lower extremity about the knee-joint, etc. Within the past few years a technique of treatment of cicatrices in all localities has been perfected, although treatment of cicatricial stenosis of the orifices of the body has profited but little from the new therapeutic accessions. Special attention is given by masseurs to the minimization of operation scars.

Among the chief indications in the management of cicatrices are the obliteration or concealment of scars which are on a level with the skin; the elevation of atrophic or depressed scars; the diminution or smoothing out of redundant scars; the mobilization of scars which adhere to the subjacent tissues; the stretching of scars which threaten to cause motor disability. Other indications involve the subjective sensations, chiefly inordinate itching and pain; and the disposition of scar tissue to injury, keloidal overgrowth, and secondary disease, such as cancerous degeneration.

Small scars of any sort may be excised and sutured. When this is impracticable the shiny, conspicuous quality of a flat scar may be effaced by tattooing with carmine according to a special process which involves the use of a multiple needle.

Simple depressed scars—isolated smallpox pits, for example—may be raised to the skin level by paraffin injections. When scars of this origin are adherent to subjacent tissues massage is indicated. One encounters in practice large areas of pits due to smallpox or acne. Persistent massage, kept up if need be for years, may show surprising results here; due very largely to detachment of adhesions. In addition to all possible variations of finger massage, the vibrator may be employed.

In the scars caused by confluent smallpox, or any analogous condition, Kolle advises the employment of decortication or peeling, in addition to other measures. This is readily brought about by penciling the area with pure carbolic acid, repeated if necessary. After such a cauterization Unna's zinc-oxide plaster mull is at once applied. This comes away of itself in four or five days. For the time being the raw surface is cleansed with a germicidal solution and dressed with an ointment.

This method is applicable to the face alone. For scars of the extremities, notably of the fingers and hands, the preliminary indication is to secure artificial hyperemia by the hot air chest followed by massage in its fullest development. At the close of the latter treatment, Bier's cups are applied. A large cup may be connected with a motor pump, so that positive and negative pressures are rapidly alternated. This alternation induces a marked vascular stimulation with a tendency to prevent adhesions.

In hypertrophic scars of the extremities similar measures are applicable, with the addition of remedies which tend to reduce directly the amount of redundant tissue. Plasters of thiosinamine or simply of "gray plaster" may conduce to this end. Electrolysis and the *x*-ray may be adjuvants in smoothing out irregular scars.

Numerous details require attention. Thus in regard to massage of scars much attention has been devoted of late to the employment of oil frictions, sand and gravel manipulation, etc. These resources fill no special indication in the treatment of scars.

In this connection something should be said of thiosinamine as a solvent of scar tissue. Originally recommended under this name many years ago, it was not until an alkaline component had been introduced—under the name of fibrolysin—that it began to attract universal attention. The favorable reports received as to its efficacy in the removal of scar tissue have been offset in some quarters by the results of systematic investigation into the action of the remedy upon living organisms in general. In 1909 Brandenburg showed (*Arch. f. klin. Chirurgie*, vol. lxxxix.) that fibrolysin is essentially an animal poison, which causes in laboratory animals apathy, somnolence, emaciation, and sterility. In the great majority of cases practitioners who have used fibrolysin have also employed the usual regulation measures in connection with the treatment of scar tissue.

Finally, we may mention ionic medication. Chlorine ions, it is said, have proved of great service in the softening and removal of cicatricial tissue, especially that following burns and the adhesion of ankylosed joints. The treatment takes a long time, but the results are said to have been excellent in some of these cases.

William G. Le Boutillier.
Edward Preble.

**Cicuta and Cicutoxin.**—See *Poisonous Plants*.

**Ciliata.**—A subdivision of the *Infusoria* in which the animals are provided with cilia during all stages. The chief orders are: *Holotricha*, with similar cilia all over the body; *Heterotricha*, with a covering of uniform cilia, and also an adoral zone surrounded by

larger plates of fused cilia or membranelles; *Hypotricha*, cilia limited to the ventral surface of the flattened body; *Peritricha*, body usually cup-shaped and cilia as a rule about adoral zone only. See *Protozoa*. A. S. P.

**Cimex.**—A genus of true bugs, *Hemiptera*. The wings are lacking or rudimentary and the mouth parts are well fitted for sucking blood. This genus contains the common bedbug, *C. lectularius* (which is peculiar to the habitation of man and is suspected of carrying certain diseases), as well as many other parasitic and semiparasitic bugs. See *Insects, parasitic*. A. S. P.

**Cimicidæ.**—A family of true bugs, order *Hemiptera*, in which the wings are absent or represented by a simple membrane. An important genus is *Cimex*. See *Insects, parasitic*. A. S. P.

**Cimicifuga.**—*Black Snakeroot; Black Cohosh.* "The dried rhizome and roots of *Cimicifuga racemosa* (L.) Nutt. (fam. *Ranunculaceæ*)." (U. S. P.) This is a large, perennial herb, with slender, upright stems, from one to two and a half meters high, smooth and cylindrical, each bearing two or three ternately compound leaves, the lower very large, twice or thrice pinnate; the upper ones successively smaller and more simple; leaflets pointed, serrate, ovate, or more or less three-lobed. Inflorescence of one or several long, slender, upright, cylindrical racemes (25 to 50 cm. long). Flowers very numerous, something over a centimeter across, consisting of four white, concave sepals, which drop as they expand, very numerous, free, slender, spreading stamens, and a single, one-celled, ovoid pistil, containing several ovules. Petals none, a few of the outer stamens somewhat petaloid.

Cimicifuga is a common American plant, growing in Canada and in most of the United States. It is collected in various parts of the country, and has been used as a medicine for nearly a century.

The rhizomes are horizontal, hard, two inches (5 cm.) or more long, about one inch (25 mm.) thick, with numerous, stout, upright, or curved branches, each terminated by a cup-shaped scar, and with numerous wiry, brittle, obtusely quadrangular roots, about one-twelfth of an inch (2 mm.) thick; the whole brownish black, nearly inodorous, and having a bitter, acrid taste. Rhizome and branches have a smooth fracture, with a large pith, surrounded by numerous sublinear, whitish wood rays, and a thin, firm bark. The roots break with a short fracture, have a thick bark, and contain a ligneous cord branching into three or four rays. Cimicifuga, it is said, should be collected in the autumn; it should be used moderately fresh, as it grows much less active with the lapse of time.

Composition.—Resin, fat, wax, gum, starch, and sugar have been found in this drug, but nothing to which its activity can be ascribed. Several analysts have reported traces of an alkaloid. The resin has been resolved into three portions, and one or more of these are regarded as representing its activity.

Action and Use.—There is no question that recently dried, or, still better, fresh, cimicifuga is an active substance. Vomiting, diarrhea, and cardiac depression are caused by large doses; faintness, restlessness, and dizziness, foul breath, and dryness of the pharynx are common results. Smaller doses are said to be tonic, to improve the appetite and digestion, and to strengthen the heart's action. It is reputed to be aphrodisiac and ecbolic, but is not at all reliable in these directions. The most important and acknowledged uses of cimicifuga are, however, established empirically. It has for many years had a reputation in chorea, and is generally believed to be useful in that obstinate disease. It is also given in chronic rheumatism, and occasionally in pulmonary troubles.

The official extract is given in doses of gr. i.–viii (0.06 to 0.5); the fluid extract, fl. ʒss–ij (2 to 4); the twenty-per-cent. tincture, fl. ʒss–ij (2 to 8.)

H. H. Rusby.

**Cinchona.**—In use, this word has three distinct significations, differing in their comprehensiveness.

*Cinchona* L. is a genus of some forty species of trees or shrubs of the family *Rubiaceæ*, natives of the eastern slope of the Andes, from Southern Bolivia northward, many of them destitute of medicinal properties, others so inferior as not to be in use.

*Cinchona, Quina, Quinquina*, and *Peruvian Bark*, in materia medica, are names applied to the barks of many of the above-mentioned species, and to at least one of another genus, which contain active alkaloids. The most of these barks are so weak and inferior that their use is to be discouraged, and mention of them is deferred until the close of this article.

*Cinchona* and *Cinchona Succirubra*, U. S. P., are the official names of a few of these barks which reach a certain standard of alkaloidal excellence, and these will now be separately considered.

Cinchona.—*Calisaya. Yellow Cinchona* or *Bark.* "The dried bark of *Cinchona ledgeriana* Moens, *Cinchona calisaya* Wedd. or of hybrids of these with other species of *Cinchona* (Fam. *Rubiaceæ*), yielding not less than five per cent. of total anhydrous cinchona alkaloids, and at least four per cent. of anhydrous ether—soluble alkaloids, when assayed by the following process." (U. S. P.)

A thorough knowledge of cinchona, even of its therapeutics, calls for a perfect understanding of this definition. *C. ledgeriana* and *C. calisaya* originated in Northern Bolivia and Southern Peru, at an elevation of 2,500 to 6,000 feet. The former was always rare and was known to the natives as "Zamba," and recognized as very superior. The hybrids were not at that time differentiated, though they were recognized as being numerous. The present alkaloidal standard was rarely reached. Indeed, the barks were for a long time not examined in this way, but were selected solely upon their appearance. The threatened extermination of the species led to their cultivation, in which the Dutch and British governments were concerned. The French made early attempts, but were not concerned in the practical operations. The history of this industry is of the greatest interest, and has an extensive literature. Only the most important facts relating to it can be here considered. The attempt was made to select the best varieties and forms for cultivation. This attempt but partially succeeded, and large quantities of inferior material came into the plantations. Mistakes of nomenclature also occurred, and some of them persist to this day. At the same time, very superior varieties also came into cultivation. These were propagated as soon as recognized, at the expense of the poorer ones. The mere processes of cultivation and soil enrichment increased the richness of the barks. Hybridization occurred freely, and was resorted to artificially, and astonishingly rich products were thus originated and multiplied. Special methods of treatment were devised, such as allowing the bark to grow with the light excluded by some covering ("mossing") and removing strips of bark to allow the spaces to be again covered under the above-mentioned condition ("renewing"), which also resulted in astonishing gains in the percentage of active constituents. At the same time that this

increase of quality was taking place, there was an even greater cheapening in the cost of producing and marketing. The result was that the wild barks were practically driven out of the market, and now occupy a very unimportant place in commerce.

The young bark is deficient in alkaloids. It reaches its full strength at from six to nine years of age, when the trunks are five to eight inches in diameter, and this "ripeness" is indicated by a characteristic appearance. The root bark is much richer than the stem bark.

The regions of cultivation are chiefly the Dutch East Indies, especially Java, and British India and Ceylon. Rather large areas of cultivation exist in Bolivia, but they are relatively unimportant, chiefly because of the great cost of getting the product to the coast. Mexico, Brazil, Jamaica, Australia, and Africa have had experimental plantations, but these have failed to become of importance. The bark, from selling in 1880 to 1885 at from three to four dollars per pound, has declined in price to a few cents, although it is of far better quality. The trees ultimately reach a great height and a trunk diameter of several feet. They are very beautiful, with opposite, large, luxuriant dark glossy-green leaves, often bright purple underneath, and large terminal lilac-like panicles of very fragrant flowers, white or of varying shades of pink or purple.

*Description.*—Detailed descriptions of the bark are for the most part no longer of importance, as manufacturers' bark, and to a great extent "druggists' bark" also, are now purchased upon the testimony of chemical assay. Nevertheless, it is perfectly easy to determine the good quality, as well as the identity of bark for pharmacists' use, by the external appearance alone. Such bark arrives mostly in the form of entire or but little broken quills. Formerly, it all arrived in this form, but economy in transportation now leads to its being broken up ("chipbark"), and this is known as manufacturers' bark. Of this, the root bark is distinguished by a brown, instead of a gray, outer surface, and by the warped curvature of the pieces, with crookedness of grain, or striation. Inferior branch bark may be known by its thinness and the lesser roughness and lesser grayness of the outer surface. Druggists' bark, in which we are more interested, is in quills of one and a half to two feet long and one or two inches in diameter. They are frequently rolled in at both edges, the so-called "double quill." The bark is two to five millimeters (1/25 to 1/5 in.) thick. The inner surface is of a light cinnamon brown and finely striate, the outer bright gray (a bluish or steel gray from Bolivia, a tawny or yellowish gray from Java). Deep, for the most part completely circular, transverse fissures mark the nodes of the stem, smaller and incomplete ones being numerous in the intervening space, and much interconnected by irregularly vertical ones. The surface thus becomes cut up into angular scales resembling those upon the tarsus of a fowl. The abundance and closeness of this "chicken-leg" marking is indicative of high quality. *C. officinalis* parentage is indicated by a broad and gaping condition to these fissures, at least the principal ones, and the bark is thicker relatively to the size of the quills. A distinct longitudinal ridging is characteristic of *C. succirubra* parentage. The bast layer has a finely splintery, the outer a short, fracture. The odor is slight but characteristic, the taste bitter and slightly astringent. The powder is light yellow, whence the common name of the bark. Flat, *tabla*, or table bark is the inner bark only, flattened out, the outer surface of a cinnamon brown color and smoothish.

*Composition.*—The distribution of the principal constituents of the cinchona barks will be exhibited in a table toward the close of this article. The nature and properties of the important individual alkaloids will be fully discussed after our discussion of the barks. Their percentage, absolutely and relatively to one another, varies with the age of the bark, as well as with the conditions described above. Exposure to rain during curing or in transit, or to sea water, also injuriously modifies the composition. As will be seen from the table of substances presented below, the variety now being considered contains about three per cent. of tannin, wax, gum, sugar, a trace of volatile oil, red coloring matter, and resin-like acids. These, however, do not require attention, except from pharmaceutical considerations, as calisaya is used for the antiperiodic effect of its alkaloids, more especially of the quinine. It contains from five to ten, rarely twelve to fifteen, per cent. of total alkaloids, about three-fourths of which is quinine. Owing to this preponderance of quinine, calisaya is used for the effect of that alkaloid (which see), and may be considered therapeutically as its equivalent. It is like the others an excellent simple bitter and tonic, but when these effects are desired the red bark is more commonly employed. The powdered bark is sometimes given, in doses of gr. x.–lx. (0.6–4.0), the equivalent of ♏x. to lx. of the official fluid extract, or of gr. ss. to iij. of quinine. The official extract is given in doses of gr. v.–xv. (0.3–1.0); the twenty per cent. tincture, fl. ʒ ss.–ij. (2.0–8.0); and the five per cent. infusion, fl. ʒ i.–ij. (30.0–60.0).

Cinchona Rubra, Red Cinchona.—"The bark of *Cinchona succirubra* Pavon, or of its hybrids yielding not less than five per cent. of anhydrous cinchona alkaloids when assayed by the process given under Cinchona." (U. S. P.) This tree is native upon the slopes of Mount Chimborazo and like the last, becomes a large tree. It also has been largely introduced to cultivation in the East Indies, but has not, in consequence, undergone such great changes. Its characters can be best discussed by comparing it with the last.

It more frequently occurs in quills, and the bark is commonly thicker and more splintery in fractures. The inner surface is usually, though not always, of a deeper color, varying to deep red. The outer surface, in typical samples, is almost wanting in the checkered, scaly appearance, and indeed fissures are commonly almost wanting. It has instead longitudinal ridges, originating in rows of warts which afterward become confluent. In old barks, these ridges become fissured longitudinally. The powder is of a deep red, which gives the common name to the bark. In general, its composition is the same as that of calisaya. It, however, contains far more red coloring matter and more astringent principles, and only about one-fifth of its alkaloid is quinine, the rest being mostly cinchonidine and cinchonine. Its properties differ accordingly. It is accounted decidedly inferior as an antiperiodic, and its use is commonly as a vegetable bitter. However, following the differences in the alkaloids described below, this is no mean antiperiodic, and is frequently of great service in cases not favorably influenced by quinine. The only official preparation is the compound tincture, or Huxham's Tincture, consisting of ten per cent. of this bark, eight of bitter orange peel, two of serpentaria, and seven and one-half of glycerin. The dose is fl. ʒ i.–iv. (4.0–16.0).

The Cinchona Alkaloids.—The alkaloids reported in cinchona barks are numerous. Many of them are known or believed to have originated in the chemical manipulation of the bark. Others exist in very small amount, or in barks which possess but little value. Most of them are therefore of chemical interest merely, and only those of practical importance will be here discussed.

*Quinine* ($C_{20}H_{24}N_2O_2+3H_2O$) is the most common, abundant, active, and important, and is thus described:

A white, flaky, amorphous, or crystalline powder, odorless, and having a very bitter taste; permanent in the air.

Soluble, at 15° C. (59° F.), in 1,670 parts of water, and in six parts of alcohol; in 760 parts of boiling water and in two parts of boiling alcohol; in twenty-three parts of ether, five parts of chloroform, and 200 parts of glycerin; also soluble in carbon disulphide, benzin, benzol, ammonia water, and diluted acids.

When heated to about 57° C. (134.6° F.), it melts; at 100° C. (212° F.), it loses about nine per cent. (or about two molecules) of its water of crystallization, the remainder being expelled at 125° C. (257° F.). The anhydrous alkaloid, when pure, melts at 173° C. (343.4° F.). Upon ignition it is consumed, leaving no residue.

Quinine has an alkaline reaction upon litmus paper.

A solution of quinine in diluted sulphuric acid has a vivid, blue fluorescence.

On treating 10 c.c. of an aqueous, acidulated solution (about 1 in 1,500) of quinine with two drops of bromine water, and then with an excess of ammonia water, the liquid will acquire an emerald-green color. With proper adjustment of the reagents, more dilute solutions will give a paler tint, while more concentrated ones will acquire a deeper color, or deposit a green precipitate.

Quinine should not impart more than a faintly yellowish tint to concentrated sulphuric acid (limit of *readily carbonizable, organic impurities*), nor produce a red color with nitric acid (difference from *morphine*).

If two grams of quinine be mixed, in a small mortar, with one gram of ammonium sulphate and 10 c.c. of distilled water, the mixture thoroughly dried on a water-bath, the residue (which should be strictly neutral to test paper) agitated with 20 c.c. of water, then allowed to macerate for half an hour at 15° C. (59° F.), with occasional agitation, and filtered through a pellet of glass-wool, 5 c.c. of the filtrate, transferred to a test-tube and gently mixed, without shaking, with 7 c.c. of ammonia water (specific gravity, 0.960), should produce a clear liquid. If the temperature during the maceration has been 16° C. (60.8° F.), 7.5 c.c. of ammonia water may be added; if 17° C. (62.8° F.), 8 c.c. (In each case, a clear liquid indicates the absence of more than small proportions of *other cinchona alkaloids.*)

Quinine yields two official preparations. *Ferri et Quininæ Citras*, or Citrate of Iron and Quinine, contains eighty-five per cent. of ferric citrate, three of citric acid, and twelve of quinine. It is slowly soluble in water and not completely soluble in alcohol. The soluble form (*Ferri et Quininæ Citras Solubilis*) is made with the addition of a little ammonia water, and is rapidly soluble in water. It is in greenish, golden-yellow scales; the former in reddish-brown scales. The dose of each is gr. v.–x. (0.3–0.6). The soluble form is used to make the bitter wine of iron (*Vinum Ferri Amarum*).

A very great number of salts, as well as a number of double salts, have been formed with quinine, nearly a hundred in all being listed by manufacturers. The following are official.

*Quinine Sulphate*, soluble in 740 parts of water, thirty of boiling water, or sixty-five of alcohol. It is neutral to litmus paper. About three-fourths of it is quinine. It enters into the formation of the official *Syrupus Ferri Quininæ et Strychninæ Phosphatum*, the dose of which is fl. ʒ i. to ij. (4.0–8.0).

*Quinine Bisulphate*, soluble in ten parts of water and thirty-two of alcohol, and acid to litmus paper. About five-eighths of it is quinine.

*Quinine Hydrobromide*, soluble in fifty-four parts of water and 0.6 of alcohol, neutral or faintly alkaline to litmus paper.

*Quinine Hydrochloride*, soluble in thirty-four parts of water and three of alcohol, reaction like the last.

*Quinine Valerianate*, soluble in 100 parts of water and five of alcohol, reaction like the last.

The acetate, citrate, bitartrate, benzoate, salicylate, and phosphate are also considerably used, as is the carbamide (hydrochlorate of quinine and urea). Being very soluble, they are specially useful for hypodermic injection.

The quinate is supplied on the guess that, being the natural salt of the living plant, it might be more efficient. It is very soluble in both water and alcohol, and is used hypodermically.

The tannate has been very much used, but most testimony is against its efficacy. It has little taste, but this is because of its great insolubility.

The arsenite, arsenate, antimonate, etc., may be regarded rather as medicinal forms of the associated substances.

*Action and Uses of Quinine.*—In using quinine it is always to be borne in mind that under alkaline conditions it is precipitated. The antiseptic properties of quinine are very similar to those of salicylic acid. It is especially antizymotic, and one-half per cent. may be added as a preservative to solutions. Advantage is taken of this property to prevent urinary decomposition by injecting it into the bladder. It may also be applied in powder or solution to unhealthy sores as a disinfectant. It is at the same time stimulating to the healing tissues, but care must be taken to avoid undue irritation. As a parasiticide it works very irregularly and, upon the whole, uncertainly; yet its domestic repute as a hair tonic is probably due to some destructive or inhibitory effect upon the microorganisms of the scalp. A solution painted upon the nares has in some cases aborted an attack of hay fever, but the mode of action is uncertain.

Quinine, so applied as to be maintained in solution, is stimulant or irritant to mucous membranes. It possesses precisely the same appetizing, stomachic, and tonic properties as other vegetable bitters, tends like them to inhibit digestion of the food mass in which it is contained, and, like them, should be administered for these purposes in small doses, well diluted and taken slowly just before meals. After long administration, gastric irritation and indigestion are very apt to be produced and may be reflected by an erythematous or urticarious eruption of the skin. In some persons even small doses will produce these very distressing symptoms. The reflex stimulation of quinine through the stomach appears to be rather unimportant. Its absorption is almost, if not wholly, from the stomach, so that the conditions for rapid absorption should be secured. There should be an abundance of water taken with it, and if drink is avoided for some time previous to the dose absorption is favored. A slight amount of alcohol favors absorption. If these conditions are observed, the very large doses required in treating the pernicious malarias of the tropics can be readily absorbed. In most cases, quinine is a remedy the effect of which is particularly strengthened by prompt absorption. Authorities are agreed that it exists in the blood as the chloride. It favors alkalinity of the blood. Elimination is almost wholly by the kidneys, except for the unabsorbed portion which passes out with the feces. Elimination begins very quickly but proceeds rather slowly.

Concerning the systemic effects of quinine after absorption, a very great amount of research has been recorded. The results are here very briefly summarized for the reason that their bearing upon the two leading therapeutic uses of the drug is very simple.

Its most important power is that of killing the malarial plasmodia and of inhibiting their propagation. This it does directly, promptly, and in proportion to the percentage in solution in the blood. This per-

fectly explains its antiperiodic properties, but not its effects in removing neuralgia and other sequelæ of malaria after the disappearance of the plasmodia from the system. It is natural to ascribe these results to the tonic action, through nutritive restoration; but sometimes the result is immediate, from large doses, and it must be due to some unexplained nerve action.

Its next most important effect is to reduce the temperature of fever, which it will not do to the normal temperature. This is done in two ways: (1) The drug has a marked power to lessen the oxidation of hemoglobin, as well as the transfer of oxygen to the tissues, thus decreasing heat production. (2) It inhibits the heat-producing centers. All metabolism and tissue waste are strongly checked, one of the factors favorable to its tonic action; consequently there is markedly decreased elimination of urea, uric acid, etc.

The above facts will partly explain the power of quinine to check inflammatory processes. This is further explained by the fact that the drug is a general depressant of vital power. It depresses both the irritability and power of muscular tissue, being thus a cardiac and arterial depressant. In this way, and by acting upon the cardiac ganglia and the vasomotor centers, it markedly reduces blood pressure. It must be understood, however, that this is a secondary effect and an effect of large doses, and that it is possible so to administer small doses as to get a slight vasomotor and cardiac stimulation, not followed by any appreciable reaction.

These facts in turn have a bearing upon the power of quinine to inhibit pus formation. The further claim is made that it checks the migration of leucocytes, as it certainly lessens their activity. Although the counter claim is made that this migration is checked only by impracticably strong solutions, the former view appears sustained. The reflex inhibitory centers are also stimulated, resulting in a pseudoreflex depression.

Quinine causes contraction of the spleen, especially if enlarged. The cerebral effect appears in contrast to the generally depressing effects, being that of a direct and prolonged increase of circulation, with correspondingly increased functional activity. This contrast is in reality misleading, as the principal cause appears to be depression or paralysis of the arterial walls, leading to local congestion. The symptoms induced constitute the state known as cinchonism, in which there is fulness in the head and often a slight dull headache, ringing in the ears, usually with some deafness, and some disorders of vision. These symptoms are taken to indicate the full physiological effect of the drug, and preliminary to acute poisoning, in which there are dizziness, blindness, and unsteady gait, going on to great muscular depression, convulsions, and generally the condition of collapse, with failure of respiration.

Most of the uses of quinine are direcly in line with its activities as above defined. As a tonic and restorative, one to three grains may be given before meals for some time.

In malaria, its great field of usefulness, the methods of administration differ widely. There are two principal rules, one to administer a few large doses, the other many small doses, and each has many adherents. The latter method is most likely to disturb the stomach. Proximity of the paroxysms to one another frequently renders the former method unavoidable, as the effects of administration during the paroxysm are not so favorable. It has been suggested that just after a paroxysm of fever the plasmodia are at their weakest and hence most easily affected by the quinine. All considered, the most rational method appears to be the administration of a large dose of five to ten grains just after the paroxysm and then say two grains every two hours to keep the system under its influence until the danger of recurring attacks is past. At intervals of seven days there is special danger of recurrence, and the prophylactic dose should be doubled at that time. After each seven days the dose may be progressively reduced, ceasing after the twenty-eighth day. If the patient continue exposed to infection, the cure need not be regarded as permanent except upon the best of evidence, and many such persons have to take quinine habitually. There can be no question of the frequent injuriousness of the drug under such circumstances, in spite of all statements to the contrary. Gastric and cutaneous disorders, as well as disturbances of sight and hearing, are not uncommon. Quinine should be used with caution when there is aural inflammation, and generally when cerebral congestion exists, and it should be lessened when gastric irritation comes on.

In the pernicious malaria of the tropics, very large doses, up to fifty or sixty grains, preferably of the bisulphate, with abundance of water, often prevents immediate death, and permits of cure. A little alcohol greatly aids its action. The disagreeable cerebral symptoms which would ensue from such large doses may be avoided by an accompanying dose of bromide. The use of mercurials favors the effects of quinine. The certainty of the antiperiodic action of quinine was established by an Indian Government commission, which determined the proportion of failures to be not more than seven per thousand cases.

The antipyretic action of this alkaloid can be secured by the administration of twenty grains or more. If the temperature is ascending at the time, more is required. It is then also slower in its action, requiring about an hour under the most favorable circumstances.

Acute tonsillitis is apt to be most favorably affected by a prompt dose of ten grains, and an impending cold may often be averted in the same way. Here, again, a small or moderate dose of alcohol will emphasize the effect of the quinine.

Various methods have been resorted to to disguise the bitter taste of this drug, exceedingly objectionable to many persons. The use of tannin and substances containing it weakens its medicinal effect. Yerba santa probably acts chiefly in this way. Probably there is nothing in the liquid form, better than licorice for this purpose. The best general method, however, is the use of the soft gelatin capsule, or, almost as good, the ordinary hard gelatin capsule.

*Other Alkaloids.*—The only other alkaloids which require mention are quinidine, cinchonidine, and cinchonine, the last of comparatively little value. As to dosage, it is taught that for antiperiodic purposes, the dose of quinidine and cinchonidine is about one-third more than that of quinine, that of cinchonine double that of quinine. The failures per thousand stand 6 for quinidine, 7 for quinine, 10 for cinchonidine, 23 for cinchonine. The relative antipyretic effects are, quinine 10, quinidine 9, cinchonidine 7, cinchonine 4. As stomachics and tonics, there is little difference among them, with the injurious effects more pronounced from quinine. Cinchonidine, and still more cinchonine, is less apt to cause the disagreeable effects of cinchonism, and they may frequently be given to those who cannot tolerate quinine. Cinchonine and its sulphate, and the sulphates of cinchonidine and quinidine, are official and their descriptions follow, as well as brief accounts of some rather important alkaloidal substances.

*Cinchonina or Cinchonine* ($C_{19}H_{22}N_2O$).—White, lustrous prisms or needles, without odor, at first almost tasteless, but soon developing a bitter aftertaste, and permanent in the air.

Soluble, at 15° C. (59° F.), in 3,760 parts of water, and in 116 parts of alcohol; in 3,500 parts of boiling water, and in 26.5 parts of boiling alcohol. Also

soluble in 526 parts of ether, and in 163 parts of chloroform.

At 240° C. (464° F.) the crystals fuse together, and at 258° C. (496.4° F.) they melt, forming a brown liquid. When ignited, they are consumed without leaving a residue.

When placed on moistened red litmus paper, cinchonine shows an alkaline reaction.

On adding to a neutral or not more than faintly acid solution of cinchonine, or of one of its salts, enough potassium ferrocyanide T. S. to redissolve the precipitate first formed, and afterward an acid, a golden-yellow precipitate will be formed, which, when redissolved by gently warming the liquid, will separate, on cooling, in minute scales or needles.

On adding an excess of ammonia water to a solution of cinchonine in a dilute acid, the alkaloid will be precipitated.

The precipitate is but feebly soluble in ammonia, and should require not less than 300 parts of ether for solution.

Its sulphate is neutral, and is soluble in sixty-six parts of water and in ten of alcohol.

*Cinchonidine Sulphate* $(C_{19}H_{22}N_2O)_2H_2SO_4+3H_2O)$. —White, silky, acicular crystals, without odor, having a very bitter taste and slightly efflorescent on exposure to air.

Soluble, at 15° C. (59° F.), in seventy parts of water, and in sixty-six parts of alcohol in 1.42 parts of boiling water, and in eight parts of boiling alcohol. Also soluble in 1,316 parts of chloroform, and almost insoluble in ether. The presence of sulphates of other cinchona alkaloids increases its solubility in ether and chloroform.

At 100° C. (212° F.) the salt gives off its water of crystallization. At 215° C. (419° F.) it melts, and, when ignited, it is consumed without leaving a residue.

The salt is neutral, or has a faintly alkaline reaction on litmus paper.

On adding ammonia water to the aqueous solution of the salt, a white precipitate (cinchonidine) is produced, which is but slightly soluble in ammonia, but dissolves in about seventy-five parts of ether.

If concentrated sulphuric acid be added to a small quantity of the salt, not more than a faintly yellowish color should be developed (limit of *readily carbonizable, organic impurities*). Upon adding to this liquid a crystal of potassium dichromate, a yellowish-green color is produced, which gradually changes to grass-green.

Addition of barium chloride T. S. to an aqueous solution of the salt produces a white precipitate insoluble in hydrochloric acid.

A solution of the salt (about 1 in 1,000) in diluted sulphuric acid should not exhibit more than a faint blue fluorescence (absence of more than traces of the *sulphates of quinine* or *quinidine*).

If one gram of the salt be dried at 100° C. (212° F.) until it ceases to lose weight, the residue, cooled in a desiccator, should weigh not less than 0.920 gram (absence of an *undue amount of water*).

If 0.5 gram of the salt be macerated, with frequent agitation, at the ordinary temperature, with 20 c.c. of distilled water, 0.5 gram of potassium sodium tartrate then added, the maceration continued, under repeated agitation, for one hour at 15° C. (59° F.), and the mixture then filtered, the addition of one drop of ammonia water to the filtrate should not produce more than a slight turbidity (absence of more than small proportions of the *sulphates of cinchonine* or *quinidine*).

*Quinidine Sulphate* $(C_{20}H_{24}N_2O_2)_2H_2SO_4+2H_2O)$ is soluble in 100 parts of water or in eight of alcohol, and is neutral or faintly alkaline.

*Quinoidine, Chinoidine,* or *Black Stick,* is a blackish, resinous, alkaloidal mass precipitated from the mother liquor and without definite composition. It is nearly equal in efficacy to quinine, and may often be used in the same dose as quinine in chronic malaria, when other alkaloids have failed, or when quinine cannot be used.

*Febrifuge* is a name applied to an alkaloidal mass manufactured in India as a cheap substitute for quinine for home consumption. One form is made of the total alkaloids of red bark, another as a by-product after the extraction of quinine, with the addition of the alkaloids of some hybrid bark. It is used on an immense scale. Its composition is reported by Hooper (*Pharmacographia Indica*) as quinine 15.1 per cent., cinchonidine twenty-nine per cent., cinchonine 33.5 per cent., amorphous alkaloids seventeen per cent. It is a pale yellowish-white powder, of peculiar odor. The dose is slightly larger than that of quinine.

Unofficial Cinchona Barks.—Only two of these are important, namely, Pale Bark and Maracaibo Bark.

*Pale Bark.*—This is the product of *Cinchona officinalis* L. and its several varieties. These vary so greatly in appearance that there are several forms of this bark recognized, as Crown, Huanuco, Cuenca, Loxa or Loja. The native bark came from Ecuador, and still does so in rather large amounts. It comes from large shrubs and occurs in rather crooked, thin quills, from the thickness of a lead pencil to that of the finger, and is rather thick for the size of the quill. It is generally of a dark brown, and Huanuco a rather light brown, and is very apt to be excessively shaggy with lichens, when it is highly prized and really contains more alkaloid, as a result of the exclusion of light during growth. It is less bitter than the other barks. It and various hybrids have come largely into cultivation, but this cultivation is not now continued on the same scale. These hybrid forms grow much larger, the quills becoming as large as an ordinary calisaya. They retain their proportionally greater thickness. They are usually of a dingy gray and the fissures are wide and gaping. The color of the powder is very light, giving the name "pale." This bark (if typical) usually contains about three per cent. of alkaloids, one-half to nearly two-thirds being quinine. It is chiefly consumed in Southern Europe. It was formerly official, and its fluid extract is still a favorite with many American physicians. This preference is however erroneous, unless a double dose is given to secure the same effect.

*Maracaibo Bark.*—This is from one of the most northerly growing species. What that species is, is not certain. The bark occurs in warped, chip-like, thick pieces commonly as large as the hand, and is of coarsely striated structure, and hard and heavy. It is of a bright but pale yellow, with silvery soft patches of periderm easily scraped off with the thumb-nail. Its only interest is because many ignorant pharmacists purchase it, under the name of "yellow bark," for calisaya. It is quite worthless except as a vegetable bitter, containing a great amount of resin, but practically no quinine or other valuable alkaloid.

The other unofficial barks, Cuprea, Pitaya, Gray, Hard, and Soft Colombian, Hard and Fibrous Carthagena, Hamalies, Cuzco, Cocola, Pajinal, are in the market, if at all, only as relics. They are no longer collected. When cinchona was valuable, great quantities of these were accumulated in London, and when the price fell they were stored to await a favorable market, which never came.

*Remijia.*—One of these, Cuprea Bark, is the product of the related genus Remijia and contains a small amount of quinine.

The following composition table by Dr. Bolles, taken from the first edition of this work, is of interest:

1. ALKALOIDS.

| Name. | Discovery. | Composition. | Source. |
|---|---|---|---|
| Quinine | Pelletier and Caventou, 1820 | $C_{20}H_{24}N_2O_2$ | In all the best cinchonas, especially *C. calisaya, ledgeriana, officinalis, lancifolia, pitayensis*, etc., associated with cinchonine, etc. |
| Quinidine | Henry and Delondre, 1833 | Same formula | *C. pitayensis* and other good species. |
| Cinchonine | Pelletier and Caventou, 1820 | $C_{19}H_{22}N_2O_2$ | Red bark, *C. succirubra*, also in most of the others, common and abundant. |
| Cinchonidine | Winckler, 1874 | Same formula | *C. tucujensis*, also in other species. |
| Homocinchonidine | Hesse, 1877 | $C_{19}H_{22}N_2O_2$ | South American red bark. |
| Quinamine | Hesse, 1872 | $C_{19}H_{24}N_2O$ | *C. ledgeriana, officinalis*, etc., also in *remijia*. |
| Cinchamidine | Hesse, 1881 | $C_{20}H_{26}N_2O$ | From the mother liquor of homocinchonidine. Frequently present in commercial cinchonidine. |
| Aricine | Pelletier and Coriol, 1829 | $C_{23}H_{26}N_2O_4$ | *C. pubescens*, etc., Arica or cusco bark. |
| Cusconine | Hesse, 1877 | $C_{23}H_{26}N_2O_4$ | Accompanying the above. |
| Cusconidine | Hesse, 1877 | Not analyzed. | |
| Cuscamine | Hesse, 1880 | Not analyzed | *C. pelletieriana* ("cusco bark"). |
| Cuscamidine | Hesse, 1880 | | |
| Paricine | Winckler, 1844 | | *C. succirubra* (Hesse, 1877). |

2. ACIDS.

| | | | |
|---|---|---|---|
| Cinchonic acid, kinic acid | Hoffman, 1790 | $C_7H_{12}O_6$ | In all cinchonas and many other plants. A widely distributed vegetable acid. |
| Chinovic acid | Hlasiwetz | $C_{26}H_{38}O_4$ | In cultivated cinchonas; probably more general. Also in Tormentilla. |
| Cinchotannic acid | Berzelius | | All cinchonas. |

3. NEUTRAL AND MISCELLANEOUS.

| | | | |
|---|---|---|---|
| Chinovin. A glucoside | Pelletier and Caventou, 1821 | $C_{30}H_{38}O_8$ | Cinchonas, Remijias, and other *Cinchoneæ*. |
| Cinchona red | Reuss, 1812 | $C_{28}H_{32}O_{14}$ | All cinchonas, especially the red. |
| Lignoin | Reichel, 1856 | $C_{20}H_{23}NO_5$ | Cinchonas—doubtful substance. |
| Cinchocerotin | Kerner, 1859 | $C_{27}H_{48}O_2$ | Calisaya. |
| Water | | | |

HENRY H. RUSBY.

**Cincinnati.**—This, the chief city of Ohio, is situated on the north bank of the Ohio River. "It is surrounded by hills from 400 to 465 feet in height, forming one of the most beautiful amphitheaters on the continent, from whose hilltops may be seen the splendid panorama of the cities below, and the winding Ohio" (Appleton's "Guide to the United States and Canada"). It is a city of 364,463 inhabitants, more than a third of whom are Germans or of German parentage. The chief public park is Eden Park, situated on a hill affording a striking view of the city, the valley of the Ohio, and the surrounding country. The climate is indicated by the accompanying chart.

CLIMATE OF CINCINNATI, OHIO.—LATITUDE, 39° 6′; LONGITUDE, 84° 30′. PERIOD OF OBSERVATIONS, DECEMBER 1, 1870, TO DECEMBER 31, 1883.

| Data. | January. | July. | Year. |
|---|---|---|---|
| Temperature (Fahr.)— | | | |
| Average or normal | 34 4° | 78 3° | 55.90° |
| Average daily range | 14 0 | 16 3 | |
| Mean of warmest | 41 4 | 86 8 | |
| Mean of coldest | 27 4 | 70 5 | |
| Highest or maximum | 69 0 | 103 5 | |
| Lowest or minimum | −10.0 | 58.2 | |
| Humidity— | | | |
| Average relative | 72 3% | 64.4% | 66% |
| Precipitation— | | | |
| Average in inches | 3 54 | 4.29 | 44.36 |
| Wind— | | | |
| Prevailing direction | S.W. | S.W. | N.W. |
| Average hourly velocity in miles | 6 4 | 4.8 | 5.8 |
| Weather— | | | |
| Average number of clear days | 4 8 | 9 2 | 94.9 |
| Average number of fair days | 10 2 | 13 2 | 140.4 |
| Average number of clear and fair days | 15.0 | 21 4 | 235.3 |

E. O. OTIS.

**Cineol.**—See *Eucalyptol*.

**Cinesthesia.**—See *Kinesthesia*.

**Cinnaldehydum.**—Cinnaldehyde, cinnamic aldehyde, $C_6H_5CH{:}CH.COH$. It is an aldehyde derived from oil of cinnamon or prepared synthetically, containing not less than ninety-five per cent. of pure cinnamic aldehyde. It is "a colorless liquid, having a cinnamon-like odor and a burning aromatic taste. It boils at about 250° C. (482° F.), with partial decomposition. It is sparingly soluble in water, soluble in all proportions in alcohol, ether, and fixed and volatile oils" (U. S. P.). Cinnamic aldehyde has been recommended in cases of phthisis in doses of ♏ i.(0.06) in capsule. It should be kept in amber-colored and well-stoppered bottles.

R. J. E. SCOTT.

**Cinnamic Acid and Cinnamates.**—Cinnamic or phenyl-acrylic acid ($C_6H_5.CH{:}CH.COOH$.) results from oxidation of oil of cinnamon, the oil being chemically cinnamic aldehyde, and it also exists ready formed in conjunction with benzoic acid, to which it is closely related, in many balsams, such as the balsams of tolu, of Peru, and of benzoin. It can be formed synthetically also. Cinnamic acid is a colorless crystalline body, volatilizable without taste or smell, freely soluble in alcohol, but only feebly so in water (one-tenth per cent.). The commercial article is obtained chiefly from styrax.

Cinnamic acid is non-poisonous, and is said to resemble salicylic and benzoic acids in antiseptic power. It has been suggested as a practical antiseptic for use in surgical dressings. Lint, jute, etc., may be charged with the acid by soakage in an alco-

holic solution. It has also been employed for the constitutional treatment of phthisis, by the intravenous injection, twice a week, of a few minims of a five-per-cent. emulsion of the acid. Such injection is practised upon a vein of the forearm with proper antiseptic precautions, and the treatment continued for at least three months. It is said to produce a leucocytosis. Dose, by mouth, one-twentieth to one-fourth grain (0.0032–0.016).

Cinnamic acid is oxidized readily into benzoic acid, and it is supposed that this action takes place in the human system, since the two acids have the same effect upon the urine and its constituents.

*Sodium cinnamate* is a salt freely soluble in water, and has been proposed as a substitute for cinnamic acid because of such free solubility. It is known under the trade name of *Hetol*. Glycerin of sodium cinnamate has been given both hypodermically and intravenously in cases of cancer and pulmonary tuberculosis.

EDWARD CURTIS.
R. J. E. SCOTT.

**Cinnamon.**—The cinnamon products include cinnamon and cassia barks, cassia chips, cassia leaves, and cassia flowers, and the oils distilled therefrom. They are all yielded by species of the genus *Cinnamomum* Blume, in the family *Lauraceæ*. The genus contains some fifty-four species, all natives of tropical Asia and Australasia. The section containing the camphor tree is markedly distinct, and would probably be better regarded as forming a separate genus. Many of the species yield useful products of minor importance and these will be enumerated at the close of this article. Two species, one of them known, the other doubtful, yield the highly esteemed and official cinnamon barks, and will now be considered separately.

1. CEYLON CINNAMON, CINNAMOMUM ZEYLANICUM.—"The inner bark of the shoots of *Cinnamomum zeylanicum* Breyne" (U. S. P.). This well-known species is a native of the hills and woods of the island of Ceylon. It has also been long cultivated in the same island, and it is from these cultivated plants that all the true cinnamon now comes. It has also been introduced into other islands of the Indian Ocean, and into the mainland of Asia, as well as into the West Indies, but it produces in these places inferior barks. On the cinnamon plantations the trees are trimmed down to make them send up sprouts from the base; these are allowed to grow until they are about two years old and three or four centimeters in diameter, when they are cut, and the bark is peeled off in pieces about thirty centimeters (1 ft.) in length. These strips are then put together in rolls and allowed to wilt for a day or so, when they are separated and each piece is laid upon a suitable stick around which it will fit, and the outer cellular layers of the bark are scraped off and rejected. The quills of inner bark so prepared constitute cinnamon, and are rolled together in successive layers until a solid cylinder about a meter long and 1.5 or 2 centimeters thick is formed (1 yd. by 0.5 or 0.75 in.), of sometimes a dozen layers of brittle, splintery bark.

*Ceylon cinnamon* is in long, closely rolled quills, composed of eight or more layers of bark of the thickness of paper; pale yellowish brown; outer surface smooth, marked with wavy lines; inner surface scarcely striate; fracture splintery; odor fragrant; taste sweet and warmly aromatic.

This is altogether the finest, and in general the best cinnamon of the market, though it is not nearly so strong, sweet, or expensive as the next variety. If taken young and of good quality, it has scarcely a trace of bitterness and but little astringency. It contains only a moderate amount of sugar and mucilage. It yields a large percentage (up to five per cent.) of ash. It is rich in oil, yielding up to one and a half per cent., and this oil is very fragrant. The features of this cinnamon, as a perfuming and flavoring agent, are its delicacy and permanence.

2. SAIGON CINNAMON, CINNAMOMUM SAIGONICUM, "GOD'S CINNAMON."—To this variety also the name *Chinese Cinnamon* is applied. "The bark of an undetermined species of Cinnamomum" (U. S. P.). We are entirely ignorant of the botanical origin of this variety. Although it has frequently been assumed that it is from the same plant which yields the last, its characters almost certainly prove the contrary. For many years we heard of a cinnamon in the unvisited regions of Southern China which was unknown in civilization, and of wondrously fine quality. Its curative properties were almost deified by the Chinese. At length some small lots were brought out, and it has now become a regular article of commerce. Little is known of the methods of its collection or drying. It comes in single quills of a foot in length, none of the outer bark being removed. These are tied neatly in bundles about ten inches in diameter. Each case contains rolls made up of bark of different respective thickness, the intermediate being the best. The thinnest is smoothish and of a dark red-brown. The others are gray or gray-brown and rough, the intermediate granular, the thickest fissured. Saigon cinnamon sometimes comes in chips of very thick bark, sometimes a third to a half inch thick. At its best, this entire thickness is free from astringency and bitterness, fragrant and very sweet, differing markedly in this character of the outer layers from either of the others. It is also peculiar in its sugary sweetness. Its aromatic property also is quite distinct, being biting rather than mild. Altogether, it is the sweetest and strongest of the cinnamons, but at the same time the least permanent as to flavor and odor. It is clearly nearer to cassia than to Ceylon cinnamon. Its best grade is much the most expensive variety of cinnamon. It is subject to substitution by a false article, very closely resembling it, both naturally and in its packing. This article is a cinnamon, and looks as though it might be selected from unpeeled cassia. The intermediate size is that adopted by the Pharmacopœia, and is thus described:

In quills about fifteen centimeters long, and ten to fifteen millimeters in diameter, the bark two or three millimeters thick; outer surface gray or light grayish-brown with whitish patches, more or less rough from numerous warts and some transverse ridges and fine longitudinal wrinkles; the inner surface cinnamon-brown or dark brown, granular and slightly striate; fracture short, granular, in the outer layer cinnamon-colored, and near the cork with numerous whitish striæ forming an almost uninterrupted line; odor fragrant; taste sweet, warmly aromatic, somewhat astringent.

3. CASSIA CINNAMON, CINNAMOMUM CASSIA, CASSIA LIGNEA, CASSIA VERA.—This variety, no longer official, is the bark of the shoots of *C. cassia* (Nees) Blume. Like Ceylon cinnamon, it is collected both from wild and from cultivated trees, mostly the latter. It comes from Southern China, and is therefore often called Chinese cinnamon. The name is a bad one, however, as it does not distinguish it from No. 2. The trees are cut down when about six years old and the long straight shoots, about an inch in thickness, are peeled in lengths of about a foot. Each quill is usually the bark from half the circumference. The outer bark is not carefully scraped away as in the last, but is roughly and imperfectly shaved off with an instrument resembling a spoke shave. The quills are dried and packed separately. The description of this species is as follows: In quills of varying length and about one millimeter or more in thickness; nearly deprived of the corky layer; yellowish-brown; outer surface somewhat rough; fracture nearly smooth; odor fragrant; taste sweet and warmly aromatic.

This variety tends much more to bitterness and astringency than the last. Its better grades also contain more sugar and gum. Its yield of oil is ordinarily less, and this is usually not quite so fine, though it is the ordinary commercial sort. The special feature of this cinnamon is its variability. Its best varieties are rather sweeter than the last in flavoring, but the taste does not endure so well. Its poorer varieties are scarcely fit for use. The best varieties are the "Java" and "Batavian." They are very carefully prepared from young shoots. The outer bark is entirely removed, the color is a pale yellow-brown, the taste fragrant, sweet, and very mucilaginous. The latter character rather disqualifies it for pharmaceutical uses, but makes it better, if anything, for culinary purposes. The poorest grades are the cheap "Chinese Mats." In preparing them, each packer has three lots of material to draw upon. First, some long quills of fair quality; second, some broken material and chips of very inferior grade; third, sand or other heavy foreign material. These he uses in regular proportions and packs neatly, with the good bark in a thin layer upon the outside. Two small rolls are sewn into a mat. Cassia is the cinnamon almost exclusively used in the household, and the most of this is of the poorer grades, besides which the ground article is enormously adulterated.

Some other cinnamon species and products, including the oil of cinnamon, are discussed below.

*Composition.*—The general composition of the bark has already been given. The only constituent that can by any reasoning be classed as medicinally active is the oil, which exists in the proportion of one-half to one and one-half per cent.

*Action and Uses.*—Aside from its use as a condiment, and as an adjuvant in the pharmacy, its properties and uses are entirely those specified under the title of the oil.

*Preparation.*—The only medicinal preparation, strictly speaking, other than those of the oil, is the ten-per-cent. tincture, made from the Ceylon variety, the dose being fl. ʒ i.–ij. (4.0–8.0). The dose of powdered cinnamon of any variety is gr. viij.–xxx. (0.5–2.0). Ceylon cinnamon enters into the aromatic powder, and Saigon into the compound tinctures of cardamom, gambir, and lavender, but none of these are proper preparations of cinnamon as such.

*Cassia Chips.*—These are the trimmings of cassia bark which cannot be utilized as cinnamon, but which yield a certain amount of oil upon distillation.

*Cassia Buds or Cassia Flowers* are the unripe fruits, not only of the species above named, but also of *C. tamala* Nees ab Eberm. and *C. dulce* N. ab E. *C. daphnoides* Sieb. and Zucc. and *C. loureirii* Nees yield a very poor quality of a false cinnamon. The leaves of *C. obtusifolium* Nees, *C. iners* Reinw., *C. nitidum* Hook., *C. tamala* N. ab E., and some other species have been articles of commerce under the name of Malabathrum leaves. The barks of various species have found minor uses in medicine, chiefly as antidiarrheal agents, acting partly by their tannin and partly by the volatile oil.

Oleum Cinnamomi.—Oil of Cinnamon. The origin of this oil has been sufficiently explained. Our Pharmacopœia directs that it be distilled from cassia cinnamon, not because that of Ceylon cinnamon is unsatisfactory, but because the two, if first class, are hardly to be distinguished, and prac.tically all of the oil of commerce comes from cassia The Pharmacopœia requires that it contain at lest seventy-fivt per cent., by volume of Cinnamic aldehyde. Much of the commercial oil is said to be distilled from the leaves. While ordinary oil of cinnamon can be had for two or three dollars a pound, that of the Ceylon brings twenty, and is no better. The following is its official description:

"A yellowish or brownish liquid, becoming darker and thicker by age and exposure to the air, having the characteristic odor of cinnamon, and a sweetish, spicy, and burning taste. Specific gravity, 1.045 to 1.055 at 25° C. (77° F.). Soluble in an equal volume of alcohol, the solution being slightly acid to litmus paper; also soluble in an equal volume of glacial acetic acid. When shaken with a saturated solution of sodium bisulphite, it solidifies to a crystalline mass. If four drops of the oil, contained in a test-tube, be cooled to 0° C. (32° F.), and then shaken with four drops of fuming nitric acid, crystalline needles or plates will be formed. If a portion of the oil be shaken with water, and the liquid passed through a wet filter, the clear filtrate should give, with a few drops of basic lead acetate T. S., a white turbidity, without a yellow color (absence of oil of cloves). If four drops of the oil be dissolved in 10 c.c. of alcohol, the subsequent addition of a drop of ferric chloride T. S. should produce a brown, but not a green or blue, color (absence of oil of cloves or of carbolic acid). If 1 c.c. of the oil be mixed with 3 c.c. of a mixture of three volumes of alcohol and one volume of water, a clear solution should result; and if to this solution there be gradually added 2 c.c. of a saturated solution of lead acetate in a mixture of three volumes of alcohol and one volume of water, no precipitate should be produced (absence of petroleum, or of colophony)."

The active constituent of this oil is *cinnamic aldehyde*, which is also official, under the title *Cinnaldehydum*. It should contain not less than seventy-five per cent. of it, and eighty-five per cent. is easily attainable. It is readily oxidized into cinnamic acid. Oil of cinnamon possessess the ordinary properties of volatile oils (see *Active Constituents of Plants*) and is peculiar among them because of its being generally regarded as the most agreeable, and because it is probably the most highly antiseptic of them all. The dose is ♏ i. to v. (0.06–0.3). We have two official preparations, the water, strength one-fifth of one per cent. and dose ʒ ss.–i. (15.0–30.0), and the spirit, strength ten per cent. and dose ♏ viii.–xxx (0.5–2.0). Henry H. Rusby.

**Circulation of the Blood.**—See *Blood, Circulation of the.*

**Circulation, Pathology of the.**—Through the normal circulation of the blood the organs and tissues of the body receive nutrition (food-stuffs, oxygen, salts, water), and are relieved of their waste products. It follows that any disturbance of the circulation must lead to changes in the life-processes of the body cells as the result of impaired nutrition. The state of the circulation is dependent upon the work of the heart, the condition of the blood-vessels, and the amount and character of the blood. Through the rhythmical contractions of the auricles and ventricles the blood is kept in motion within the vessels, where it flows under a certain pressure which is dependent upon the elasticity of the vessel walls and the amount of peripheral resistance. This pressure is relatively high throughout the systemic arterial circulation, but is low in the veins. The venous pressure, however, varies with the location of the vein, being greatest where the vessel supports a high column of blood. In the great veins of the thorax the pressure is very slight, or negative during inspiration when the negative pressure within the thorax causes an aspiration of the blood from the veins outside of the thoracic cavity. In forced expiration the pressure within both thoracic and systemic veins is increased. The factors directly controlling the blood pressure are: the mass of blood, the work of the heart, and the resistance of the blood-vessels. The latter factor is chiefly dependent upon the degree of tension exerted by the elastic contractile vessel walls. In the systemic circulation the tension is normally much greater than that in the pulmonary vessels; the

pressure in the pulmonary artery being only about one-third of that in the aorta. Potain (1902) gives the systolic pressure in an adult under normal conditions as about 170 mm. of mercury in the radial artery, but varying from 89 mm. at ages 8–10 to 220 mm. at ages 60–80 years. According to Erlanger, the average pressure in the brachial is 110 mm. systolic pressure and 65 mm. diastolic. For the same artery v. Recklinghausen gives 116 systolic and 73 diastolic pressure. The arterial blood pressure is affected by posture, psychical influences, exercise, bathing, eating, etc., and shows a definite daily range of variation.

The work of the heart is governed by the condition of its muscle and ganglia, and of the nerves and centers regulating its action. The blood-vessels are also under nervous control, and the circulatory conditions are influenced to a large extent by this innervation as well as by changes in the walls themselves. Every lesion of the heart or blood-vessels, as well as any disturbance of the nervous mechanism controlling the blood flow, will be followed by pathological disturbances in the circulation in case such lesions are not compensated by increased work of other parts of the circulatory apparatus. Further, the tone of the heart muscle and blood-vessels as well as that of the ganglia and nerve centers is directly affected by pathological changes in the amount or composition of the blood; therefore the pathological states of the circulation arise as the result of those pathological changes which lead either to disturbances of heart or blood-vessel function or to an altered state of the blood. These may be considered in the following order.

I. General Disturbances of the Circulation.—The general disturbances of the circulation may be the result of some impairment of the heart's action, vascular disturbances, or changes in the blood.

1. *Impairment of Cardiac Efficiency.*—An increase in the rate of the heart's contractions without decrease in force causes an increased velocity of the blood flow with rise of arterial pressure. The force of each beat may or may not be increased at the same time, or it may be strengthened without change in the rate. The effect upon the circulation is the same at first in both cases. As a result of increased muscular activity the heart undergoes a compensatory hypertrophy in case its nutrition is properly kept up. When both rate and force are increased the compensatory reserve of the heart muscle is sooner exhausted as the short diastoles lead to fatigue, the products of waste are not thoroughly removed, and the nutrition of the muscle suffers. As a result fatty degeneration may take place, and with this a failure of compensation. As long as the nutrition of the muscle is kept up to meet the increased demand compensation will be maintained. The left ventricle is the first to become hypertrophic, but as the right ventricle receives a larger amount of blood during diastole because of the quickening of the blood current its muscle has also an increased amount of work to perform and likewise becomes enlarged. The increased work of the heart may be caused by excessive bodily labor, over-exercise ("athletic heart"), high living, abnormal irritability of the cardiac nerves ("smoker's heart," "sexual heart,"), etc. Obstruction to the outflow of blood from the heart or in the aorta, abnormal positions of spine or thorax, chronic nephritis, etc., may also be accompanied by increase in rate and strength of the heart's action. Disturbances of the circulation will arise whenever the normal relation between the driving power of the heart and the peripheral resistance is altered. In all of these conditions when compensation is fully maintained the pulse is full, quick, and of high tension. The heart sounds are increased in force, especially the aortic second sound. The first sound at the apex is frequently accompanied by a soft blowing murmur even when compensation appears to be perfect.

The efficiency of the work of the heart may be impaired by pathological changes in the heart muscle: anemic infarction, fatty degeneration and infiltration, atrophy, coagulation necrosis, myocarditis, etc. In the acute infectious fevers and in many of the intoxications, trophic disturbances, prolonged overwork, etc., the heart may become inadequate without discoverable anatomical changes. Obstruction of the coronary vessels may lead to heart failure so rapidly that the anatomical changes produced may be too slight to be recognized. Likewise in the acute heart failure resulting from a sudden overstrain no microscopical changes may be found in the heart muscle. Pericardial and pleural adhesions and effusions, deformities of the thorax, thoracic tumors, aneurysms, high position of the diaphragm, etc., may hinder the filling of the heart during diastole, so that the blood becomes dammed back in the venous system while a less amount is supplied to the aorta. Pericardial adhesions may also hinder the amplitude of the systole. Stenosis and insufficiency of the valves of the heart are the most common and important causes of impaired heart's action. In stenosis of any valvular orifice the onward flow of blood is impeded; in insufficiency of the mitral and tricuspid the ventricular systole forces blood back into the auricles, and in pulmonary and aortic insufficiency there is during diastole a backward flow into the ventricles. Valvular vegetations, thrombi either free or situated upon the valves or between the trabeculæ of the heart muscle, may interfere with the free passage of the blood through the heart. Congenital defects of the heart (patent foramen ovale, open ductus Botalli, etc.) may also cause the most marked impairment of the heart's action.

The effects of impairment of cardiac efficiency are in all cases the same: there is a decreased amount of blood supplied to the arteries, and an overfilling of the veins. This leads to a fall in arterial pressure, while the venous pressure rises. As a result of the engorgement of the veins and capillaries, the surface of the body becomes cyanotic, and stagnation edema may occur. If the difference between arterial and venous pressure reaches a certain minimum, stasis results. When the cause of impaired efficiency is located in the left side of the heart there is first manifested an overfilling of the pulmonary circulation. This leads to increased work on the part of the right ventricle resulting in compensatory hypertrophy. When the cause is located on the right side the blood is dammed back into the systemic veins, while in the aorta and pulmonary circulation there is a fall of pressure and diminished supply of blood. The damming back of the venous blood into the large thoracic veins may cause an exaggeration of the normal venous pulse (negative venous pulse) in these veins, and in case the vessels are so distended that the valves of the jugular bulb become inadequate this pulse may extend beyond the bulb into the veins of the neck and head. It is presystolic in time, occurring synchronously with the auricular systole. If the dilatation of the right side of the heart becomes so great that the tricuspid valves are rendered inadequate, or if an organic insufficiency of these valves is present, a second venous pulsation (positive venous pulse) may be produced. This is systolic in time, being caused by a backward flow of blood through the tricuspid opening during the contraction of the right ventricle. The extreme engorgement of the veins in tricuspid insufficiency may lead to pulsations of the liver, which may become greatly enlarged from the overfilling of the hepatic veins.

In all conditions in which the contractions of the heart become infrequent and weakened, the arterial pulse is slow, soft, and small in volume. Such a pulse wave ("pulsus tardus") is seen in aortic stenosis. In insufficiency of the aorta or pulmonary artery a normal, or, as is usually the case, an increased amount of blood is thrown into the artery during sys-

tole, while in diastole a partial regurgitation into the ventricles occurs. This causes a sudden fall of tension in the artery which in aortic insufficiency is manifested in the so-called "water-hammer" pulse ("pulsus celer"). The sudden increase of pressure from the excess of blood thrown into the aorta causes a dilatation of the whole arterial system, and also of the capillaries, which may show marked pulsation. Impairment of the cardiac action is also manifested by changes in the rate and rhythm of the pulse, as an increased rate (*tachycardia*), slow rate (*bradycardia*) or irregularity. Tachycardia may be produced experimentally by section of the vagus. It occurs pathologically as the result of disease of the vagus center, paralysis of the vagus, action of various poisons (atropine), exophthalmic goiter (thyreotoxic tachycardia), in severe anemias, neurasthenia, conditions of low arterial pressure, etc. Bradycardia may be produced by stimulation of the vagus. It occurs in meningitis, cerebral hemorrhages, icterus, uremia, increased blood pressure, certain poisons, and infections affecting the heart muscle, etc. As a result of a long-continued bradycardia the arterial pressure sinks and venous congestion follows. Disturbances in the rhythm of the heart's action (*pulsus irregularis, pulsus alternans, gallop rhythm, extrasystoles, hemisystole, heartblock, dissociation,* etc.) are attracting much attention at the present time from the clinical side. As the result of such disturbances the entire circulatory system is affected in various ways, the blood pressure is lowered in the arteries, and raised in the veins. Such irregularities in the rhythm depend upon disturbances in the automatic excitation of the heart's action (Keith-Flack node) and its regular extension from auricle to ventricle (bundle of His). Abnormal stimulation of the automatic regulation gives rise to extra-systoles in either auricle or ventricle or both (pulsus bigeminus or trigeminus). An absolute irregularity (pulsus irregularis perpetuus) may arise as the result of abnormal conditions affecting the Keith-Flack node. Pathological changes in the bundle of His lead to heart-block and dissociation of auricular and ventricular systoles (Adams-Stokes symptom-complex). The other varieties of arrhythmia represent severe forms of cardiac insufficiency or even agonal phenomena.

In all forms of valvular lesions that part of the heart which is called upon for increased work undergoes a compensatory hypertrophy if conditions of nutrition are good. In stenosis of the mitral orifice the chief work falls upon the right ventricle, which becomes hypertrophied; in mitral insufficiency there is also hypertrophy of the left ventricle, caused by the increased amount of blood which comes to it from the greater flow sent through the lungs by the right ventricle. In stenosis of the pulmonary and aortic orifices the corresponding ventricle becomes enlarged. Since the auricles have but little power of hypertrophy, lesions of the tricuspid valve are most unfavorable inasmuch as they cannot be compensated. In any form of valvular disease compensation becomes inadequate as soon as the heart is driven to the point of fatigue; that is, as soon as the period of diastole becomes so shortened that the products of tissue metabolism cannot be removed and the building-up of the muscle takes place in the proper degree. Combinations of valvular lesions are common, and may in part compensate for each other, but usually only imperfectly. Besides the alterations in the circulation manifested by the pulse, valvular lesions give rise to marked changes in the sounds of the heart, pathological sounds (murmurs) of varying quality and intensity being produced.

The results of disturbances of cardiac function are a general slowing of the blood stream with arterial anemia and general passive congestion (*cyanosis*). With increasing cardiac insufficiency *hypostasis* of the dependent portions of the body, particularly important in the lungs, takes place; and finally the heart's action may cease entirely.

2. *Disturbances Resulting from Changes in the Vascular System.*—The blood pressure in both the systemic and pulmonary arteries varies within certain physiological limits. The form of the vessels is dependent chiefly upon nervous influences (vasoconstrictor and vasodilator), but also partly upon the action of certain internal secretions (adrenalin) upon the muscle cells or upon the nerve endings in the wall. Through the influence of many widely differing pathological conditions these limits may be overstepped, and an abnormal increase or diminution of arterial pressure may result. Increase of pressure in the aorta may be due to an obstruction in the aorta or in the larger arterial branches, or to vascular contraction involving the entire corporeal circulation or vascular areas large enough to affect the entire circulation. Increased aortic resistance may be caused by stenosis of any portion of the vessel, congenital hypoplasia of the entire aorta or of a portion of its course, aortic thrombosis, aneurysm, changes in its wall due to arteriosclerosis and inflammation, or to dilatation of its lumen due to loss of elasticity of its walls following sclerotic changes. Contraction of the peripheral arterioles with resulting increase of pressure in the aorta may be caused by an excess of carbonic acid in the blood. In chronic nephritis there is a permanent increase in the general arterial pressure, the cause of which is as yet uncertain. It may be due to the direct action of retained urinary poisons upon the blood-vessel walls, or upon the vasomotor centers, or to reflex stimulation of the vessels or heart. In whatever way it may be caused, the increase of arterial pressure has been conclusively shown to be due to increased peripheral resistance resulting from the contraction of the smaller arterioles (hypertonic diathesis). As a result of this increased resistance the heart undergoes a compensatory hypertrophy. It is possible, however, that the enlargement of the heart, in part at least, may be due to an increased stimulation of the heart itself. Chronic intoxications from various poisons as lead, ergot, etc., likewise lead to increased arterial pressure, which may be due either to the direct effect of the poison upon the vessel wall or nerves or to changes in the kidneys. As the result of increased arterial pressure rupture of diseased arteries (cerebral) may be brought about by emotion, straining, use of alcohol, excessive exercise, sexual intercourse, etc.

Arterial pressure in the systemic circulation may be diminished by bacterial toxins and various poisons acting upon the vasomotor center, severe hemorrhage, relaxation of arterial tone following paralysis of the vasomotor system, cerebral hemorrhage, syncope, shock, hysteria, psychical excitement, injuries to the cervical cord, etc. When this decrease of pressure occurs, the blood passes too rapidly from the arteries into the veins, the pressure in the two systems tends to become equal, so that when a certain minimum of difference is reached stasis occurs. When the fall in blood pressure occurs rapidly symptoms of collapse appear.

Increase of pressure in the pulmonary circulation may be caused by obstruction of a portion of the lung capillaries, inflammatory conditions of the lungs and pleura, atrophy, emphysema, indurations and retractions, pleural adhesions and effusions, thoracic deformities, tumors, aneurysms, etc. When the pulmonary obstruction is but slight, it may be entirely overcome by collateral dilatation; if the obstacle is large enough to cause the pulmonary pressure to rise, compensatory hypertrophy of the right ventricle will follow.

The pulmonary pressure may be decreased as a result of valvular lesions of the right heart, thrombosis, weakness of the muscle of the right heart, etc.

A decrease in the negative pressure in the right side of the thorax, caused by pneumothorax, pleural effusions, high position of the diaphragm, etc., hinders the aspiration of blood into the right heart, and causes a general damming back of the venous blood and a deficiency in the pulmonary and arterial systems. If this decrease of negative pressure is very sudden, as in right-sided pneumothorax, the blood may flow back out of the right auricle into the veins.

Changes in the tension of the systemic circulation are recognized by the palpation of the radial pulse; those of the pulmonary system by the auscultation of the pulmonary second sound, which varies in strength according to the tension in the pulmonary artery. The clinical value of this sound is so great that it has been called the "pulmonary pulse."

II. Local Disturbances of the Circulation.—The regulation of the amount of blood which an organ or tissue receives under normal conditions is affected by changes in the caliber of the afferent vessels. These changes are primarily dependent upon the elasticity of the vessel wall and the power of contraction possessed by its muscular coats. The latter are controlled by nervous impulses arising from the vessel plexuses or from the vasomotor centers in the medulla and cord. These impulses may be direct or reflex, and either inhibitory or stimulative in character. As the total amount of blood in the body is not sufficient to fill all of the vessels to their fullest capacity at the same time, it follows that at certain times some of the organs may be richly supplied with blood, while others contain but little. The former condition is designated as hyperemia, the latter as anemia. When these conditions become protracted in time or of excessive degree, the hyperemia or anemia is to be regarded as pathological.

1. *Hyperemia.*—This may be either active (arterial congestion) or passive (venous congestion). The former depends upon an increase in the arterial supply; the latter is caused by obstruction to the venous outflow.

Arterial congestion may be either collateral or idiopathic. The first plays but a slight rôle pathologically. It is merely the result of a diminished flow to other parts, and is found in the immediate neighborhood of parts whose blood supply has been decreased or entirely shut off, as around an anemic infarct. An active hyperemia of the internal organs may be caused by a contraction of the peripheral vessels, as in a chill. In carbonic monoxide poisoning more than half of the volume of blood may be gathered in the blood-vessels of the abdominal cavity. Idiopathic active congestion is of much greater pathological importance. It depends upon a dilatation of the vessel, due either to paralysis of the vasoconstrictors, stimulation of the vasodilators, direct action upon the muscular coats, or a lessening of the external pressure exerted upon the vessels. Neuroparalytic congestion may be caused by injury or section of the cervical sympathetic; as in a case of gunshot wound of the right cervical sympathetic, unilateral flushings of the face were caused by slight exertions. The unilateral congestions in migraine and various forms of neuralgias may also belong to this class; likewise the phenomena observed in shock, where paralysis of the splanchnic leads to an extreme active congestion of the abdominal vessels. Many of the local hyperemias common in hysterical cases may also be explained as being of the nature of neurotic congestions, but between the paralytic form and that due to stimulation of the vasodilators no clear line can yet be drawn except in experimental work. Direct weakening of the muscles of the blood-vessel walls may be caused by the action of heat, trauma, disturbances of blood current, action of certain drugs, as atropine, chlorine, ammonia, etc. Active congestion of the abdominal vessels follows the removal of ascitic fluid; likewise, in stenosis of the upper respiratory tract, the decreased pressure in the alveoli of the lungs leads to active dilatation of the pulmonary arterioles and capillaries. Active congestion is manifested clinically by redness, swelling, and increased warmth of the affected area. The color is that of arterial blood. The clinical picture resembles that of inflammation, in which process active congestion plays a very important rôle.

Local venous hyperemia may be caused by compression, ligation, direct pressure upon the vein by tumor or pregnant uterus, venous thrombosis, extension of malignant growths into the lumen of the vein, gummata, etc. In cirrhosis of the liver the obliteration of the intrahepatic branches of the portal leads to chronic passive congestion of all the branches making up the portal together with their collaterals (caput medusæ, esophageal hemorrhoids, etc.). Pressure upon the superior vena cava by mediastinal tumors leads to a dilatation of the superficial veins of the thorax and abdomen from the establishment of a collateral venous circulation through these branches. The flow of blood from the lower extremities may be retarded by lack of proper aid from muscular action, as in the case of varicose veins in individuals who lead sedentary lives or who stand in one position for a great part of the time. This form of congestion is also favored by the anatomical peculiarities of certain veins: the hemorrhoidal, for example, containing no valves, are easily affected by disturbances of the venous circulation through the liver, since the blood from these vessels is obliged to traverse a second set of capillaries in this organ. Hemorrhoids are on this account one of the earliest symptoms of hepatic obstruction. The branches of the left spermatic vein are also predisposed to passive congestion, from the fact that this vessel empties at right angles into the left renal vein.

The obstruction to the flow of blood in any single vein is usually of slight consequence if the vessel has free anastomosis with other veins, but if the collateral circulation is insufficient partial or complete stasis must result which may lead to thrombosis. Frequently the dilatations of the veins behind the point of obstruction may overcome this, and the flow become reëstablished, or the small anastomosing veins may become stretched until they are adequate to carry on the obstructed circulation. In this way small veins may become changed into vessels of large size. Even after thrombosis the lumen of the vein may be partly restored by contraction of the thrombus and formation of new channels in the tissue resulting from the organization of the thrombus. The contraction of this newly formed tissue also aids in the formation of new blood-channels. Direct anastomosis between veins and arteries may also occur.

The clinical signs of passive congestion are most manifest in the extremities, tips of the fingers, ears, and nose. When the congestion extends into the capillaries, the tissues acquire a reddish-blue color (cyanosis), become somewhat swollen, inelastic, and warmer to the touch. In thrombosis of either the superior or inferior vena cava the corresponding half of the body supplying these vessels becomes cyanotic. Enlargement of the liver, venous pulsations, stagnation-edema, etc., are important clinical features of general venous congestion. Both active and passive hyperemia may disappear after death. The contraction of the vessel-walls in rigor mortis forces the blood out of the smaller vessels into the large veins and auricles. Extreme passive congestion usually persists to a greater or lesser extent after death.

*Hypostasis* (*Cadaveric Lividity*).—After death the blood in the arteries is driven into the veins by the contraction of the arterial walls, so that within a short time after the beginning of rigor mortis the

entire mass of blood is found in the veins and auricles, while the arteries and ventricles are contracted and empty. The blood thus collected in the veins tends, through gravity, to sink to the dependent portions of the cadaver, so that within a few hours after death reddish or bluish patches of coloration appear over these parts. If the body lies in the usual position upon its back, those portions of the back not pressed upon by the weight of the body become hypostatic. In a cadaver kept in an upright position the hypostasis would be confined to the lower extremities. Postmortem hypostasis is more marked in those cases in which there has been a general passive congestion before death. Pressure upon the hypostatic areas causes them to become pale, and cutting into them with a knife produces hemorrhage from the dilated veins. In carbon monoxide poisoning the hypostatic areas are of a bright cherry-red color; in poisoning by potassium chlorate they are of a dirty chocolate-brown. Postmortem hypostasi salso appears in the internal organs, to the most marked degree in the lungs and meninges. In these regions it is often mistaken at the autopsy for pathological conditions. Antemortem hypostasis of the internal organs, especially of the lungs, may result from weakened heart's action. This is most likely to occur in failure of compensation in chronic valvular disease and in prolonged fevers or severe cachexias. As the force of the blood flow becomes decreased, it is not able to drive the blood ahead with sufficient power to overcome the force of gravity, so that a hyperemic condition of the lower portions of the lungs is produced which gradually leads to stasis. As a result the circulation is further impeded and death may be hastened.

2. *Anemia.*—A diminution in the total amount of the blood leads to marked disturbances in the circulatory system, which are in direct proportion to the amount of blood lost and to the rapidity of the loss. A sudden hemorrhage of 0.5 kilogram in the adult will cause syncope. The blood pressure becomes greatly reduced, the pulse becomes small, fluttering, and frequent, owing to the lessened stimulation of the vagus. The peripheral vessels are contracted, the skin becomes pale and cold, while in the abdominal vessels there is usually dilatation, *i.e.* hyperemia. This may lead to stasis as a result of the weakened heart's action. As soon as the amount of blood sent from the heart becomes too small to supply the respiratory centers in the medulla, symptoms of asphyxia appear, and death finally takes place. This may result when less than one-half of the normal amount of the blood in the body is lost, if there is a sudden anemia of the nerve centers. The loss of much larger amounts may be borne if the hemorrhage is extended over a long period of time. When the loss of blood is not excessive, the stimulation of the vasomotor center through local anemia leads to contraction of the vessels, through which means the pressure is gradually raised. The fluid mass of the blood is quickly replaced by absorption of the tissue fluids through the activity of the cells of the blood-vessel walls. After a longer period of time complete regeneration of the corpuscular elements takes place. In anhydremia caused by the sudden removal of large quantities of fluid from the body, as in excessive diarrheas, etc., the effects upon the circulation are practically the same as those resulting from hemorrhage. In chronic anemias due to long-continued decrease in the mass of the blood, blood pressure is lowered and the heart beat slowed. The circulatory apparatus gradually adapts itself to the new conditions, and both heart and blood-vessels become atrophic. Atrophy and fatty degeneration of all the internal organs also take place. Similar changes take place in the forms of anemia due to changes in the red cells, hemoglobin, etc.

Local anemia or ischemia is the result of a diminished flow of blood to certain organs or tissues. The total mass of the blood may be normal, or the local anemia may be coincident with a general anemia due to changes in the blood as a whole. Local deprivation of blood supply may be caused by ligation, obstruction, embolism, thrombosis, compression, or disease of the vessel walls, or any cause which may act as an obstruction to the afferent arteries of the parts affected. Collateral local anemia may also occur, but plays but a slight pathological rôle. Local anemia may also be of neurotic origin, dependent upon increased resistance due to vasomotor contraction.

3. *Infarction.*—In the anemic area there results a slowing and diminution of the blood-stream, which is directly proportionate to the degree of obstruction of the artery. If the vessel is completely occluded the blood-current comes at once to a complete stasis. If the part is well supplied with anastomosing collaterals the anemia may be compensated by an increased flow through the branches, which eventually become greatly dilated and hypertrophied, so that the restoration of the circulation may be complete. If the anemic area is supplied by a terminal artery which is poorly supplied with collaterals, the blood of the part beyond the point of obstruction is gradually pressed out by the contraction of the tissues about the vessels until the pressure in the anemic vessels reaches that of the capillaries or is even less than it, so that a backward flow may take place to a slight extent. This is not sufficient for the nourishment of the affected area, so the tissues thus shut off from nutrition either gradually or quickly die. The parenchymatous cells first undergo necrosis, later the endothelium and connective-tissue cells. Such a dead area is spoken of as an anemic infarct.

If the obstructed artery is supplied with collaterals, the blood-pressure in the vessel beyond the obstruction after sinking to a certain minimum will rise again because of the afflux of blood from the collateral veins and capillaries. If these are capable of dilatation, as is frequently the case under normal conditions, the nutrition of the part may not suffer and no anemic necrosis follow. For this reason the obstruction of a terminal artery in the lung or in the mesentery will not, under normal conditions, lead to infarction; but if the circulation in these regions is already so disturbed that the collateral anastomosis does not yield sufficient nutrition to the part, death will result. Since the blood-vessels under these circumstances contain a greater or lesser amount of blood, the damage to the vessel-walls leads to escape of the blood either by diapedesis or by rupture. The necrotic tissue then becomes infiltrated with blood, and the area thus affected is known as a hemorrhagic infarct. The latter is in fact only an anemic infarct which has become infiltrated with blood which comes into the damaged area from neighboring collaterals. Anemic infarcts occur in the brain, heart, liver, spleen, kidneys, and muscles; hemorrhagic infarcts only in the lungs and mesentery.

About the periphery of the anemic infarct there is always seen a narrow zone of hemorrhage and congestion. This is in reality a narrow line of hemorrhagic infarct surrounding the anemic area, and is produced by the limited collateral anastomosis. To the naked eye all anemic tissues appear pale. They are also softer than normal, and the color proper of the tissue is more distinctly brought out. An anemic infarct is grayish or yellowish in color, and cheesy in consistence. In the early stage it is elevated and outlined by a narrow zone of bright red. Later the necrosed area becomes contracted from the absorption or organization of the infarct. Through the contraction of the newly formed tissue deep fissures or grooves may be formed in the surface of the organ. The fresh hemorrhagic infarct of the lungs is dark red, elevated, and firm; later it becomes

brown and undergoes softening and shrinking. Since the tissues are dead in both conditions the sequelæ of both anemic and hemorrhagic infarctions are the same as those of necrotic tissue in general: absorption, organization, sequestration, calcification, etc. Obstruction to the venous outflow produces a damming back of blood, which may be followed by extensive and destructive extravasations. The term hemorrhagic infarct has also been applied to this condition, but it seems best to restrict its use to the anemic necrosis which is followed by hemorrhage, and to classify this condition under hemorrhage. The rapidity and completeness of the development of a collateral circulation after arterial obstruction depend entirely upon the size and distensibility of the collateral branches. In some cases small capillaries or arterioles become changed in a few weeks to large-sized vessels.

4. *Changes in Current.*—As a result of varying conditions in and around the blood-vessels, retrograde currents may at times be produced. These occur most frequently in those veins subjected to pressure resulting from muscular activity. Removal of abnormal pressure by the withdrawal of pleuritic and peritoneal effusions, decrease in the intrathoracic pressure, etc., may cause a reversed current in the large veins near the heart. Compression, ligation, and obstruction of the veins from any cause may lead temporarily to the production of abnormal currents. Collateral local hyperemia may have the same effect. Such abnormal currents play an important part in the retrograde metastasis of tumor cells and infective emboli. Eddies are also occasionally set up in the veins at the point where a rapid current from one branch is mingled with a slow one coming from another. As these currents of different velocities come together eddies are formed which may favor the formation of a thrombus.

With the slowing of the blood current in any vessel the difference between the peripheral and axial zones of the stream becomes less and less distinct. When a certain degree of slowing is reached, the red cells pass into the peripheral stream and this difference is lost altogether. A clot formed on the vessel wall under such conditions will be composed chiefly of red cells. If the current is but slightly slowed, the peripheral stream contains only leucocytes, and a thrombus formed upon the wall under these conditions will be composed only of fibrin, blood-plates, and leucocytes. Alternations in the velocity of the current will lead to the formation of laminated thrombi. However, such changes in current do not always in themselves lead to the production of thrombosis.

5. *Stasis.*—This term should be applied to the complete stoppage of the blood current. This may take place either when the vessels are full of blood or when they are empty; hence we may distinguish an anemic and a hyperemic stasis. In the former the vessel is collapsed and the red cells are not crowded together. Such stoppage may occur in collateral anemia or in a general or local anemia due to any cause. Hyperemic stasis is more common and is subsequent to excessive hyperemia, in which the red cells are forced into the vessels under such great pressure that their outlines cannot be made out. The dilated vessel appears as if filled with a homogeneous scarlet mass. If the obstruction is removed before coagulation takes place, the red cells become separated and the circulation is restored. If the stoppage is of long duration, thrombosis takes place. Stasis is also produced by evaporation (exposure of the intestines during laparotomy), heat, cold, alcohol, chloroform, concentrated sugar and salt solutions, or any substance which has the power of quickly abstracting fluid from the blood, injuring the vessel wall, or causing destruction of the blood-corpuscles. As a result of stasis a gangrenous necrosis of the affected part may take place.

6. *Coagulation.*—Sooner or later after death the blood in the vessels and heart undergoes coagulation. As this usually takes place when the red cells are uniformly distributed throughout the blood, a red clot is formed (cruor, currant-jelly clot, postmortem clot). In leukemic blood the postmortem jelly clot may be yellowish or grayish throughout, having an appearance like that of pus. In the heart and in the large veins the red cells may settle to the lower side of the vessel before coagulation takes place, so that after clotting, the upper layer of the clots which may contain but few red cells, has a yellowish or grayish appearance (postmortem mixed clot). Antemortem or agonal clots are also formed in cases of slow death, where there is a gradually progressive heart failure. These form only in the peripheral stream of the heart and larger vessels, chiefly in the auricles and venæ cavæ. They contain, therefore, few red cells and have a grayish or yellowish appearance. The greater the number of leucocytes contained in the clot the more yellow its color. Toward the axial stream the clot may contain red cells, or when the current is greatly slowed, or there are alterations of rapid and slow velocity, the antemortem clot may be mixed or laminated. Such clots are not infrequently mistaken at autopsy for thrombi. They can be distinguished from these by their consistence, size, position, and the fact that they are nowhere adherent to the vessel-wall. Coagulation of extravasated blood may also take place either in the tissues or in any of the body cavities. Such clots are usually red, but may be mixed as a result of the settling of the red cells before coagulation begins.

7. *Thrombosis.*—If coagulation takes place within the heart or vessels during life as a result of changes in the vessel-wall, in the blood-current, or in the quality of the blood the process is known as thrombosis, and the resulting clot a thrombus. The first stage of the process consists in the deposit of blood-plates upon the intima at the point of injury. These become fused into a granular mass, leucocytes collect and are included in the blood-plate mass, and finally stringy fibrin is deposited. If the blood current is strong and the thrombus does not extend into the axial stream, a white thrombus will be formed, composed only of hyaline and stringy fibrin with a greater or lesser number of leucocytes. If the current is very slow, a red thrombus results through the inclusion of red cells, which with the slowing of the current pass into the peripheral stream; or, if there are alterations of velocity, laminated thrombi may be formed.

The causes of thrombosis are to be referred primarily to changes in the vessel-wall: arteriosclerosis, fatty degeneration, calcification, inflammation, necrotic processes, the various changes in the vessel-wall produced by the infections and intoxications, direct injury, etc. Impaired efficiency of the heart's action from any cause, dilatation, compression, or stricture of the vessels may also lead to thrombosis. Further, changes in the blood, as in superficial burns, intoxications, anemia, cachexia, etc., favor coagulation.

The sequelæ of thrombosis are: contraction, simple softening, absorption, purulent softening, organization, and calcification. Embolism may result if the thrombus becomes dislodged and is carried away with the blood-current. Obturation of a terminal artery by thrombosis leads to either hemorrhagic or anemic infarction. Thrombosis of veins produces venous stasis, hemorrhage, etc. The most favorable sequela is organization, the most unfavorable purulent softening, since this leads to the metastasis of emboli containing pus organisms.

8. *Embolism.*—The dislodging of a portion of a thrombus or antemortem clot and its metastasis by the blood-current to other parts of the vascular system where it is unable to pass the lumen is called

embolism, and the portion of clot transported is called an embolus. This will have the same structure as the parent thrombus; but after lodgment in a vessel a secondary thrombus of different structure may be formed upon the embolus. The sequelæ of embolism are essentially the same as those of thrombosis. Metastasis may take place either in the direction of the current (direct) or in the reversed direction (retrograde), or the embolus may pass from the venous to the arterial system through a patent foramen ovale or ductus Botalli (paradoxical or crossed embolism).

9. *Hemorrhage.*—Any escape of blood from the vascular system is styled a hemorrhage. This may take place either by rupture (rhexis) or by diapedesis. In the latter form the constituents of the blood pass through the vessel-walls without appreciable lesion of the latter. Hemorrhage from arteries occurs by rhexis only, from veins and capillaries by both rhexis and diapedesis. The size of the hemorrhage bears no distinct relation to the manner of escape. Large hemorrhages may be caused by either rhexis or diapedesis. The causes of hemorrhage by rhexis are: mechanical injury, diseased conditions of the vessel-wall, increase of intravascular pressure, and decrease of external pressure. In the arteries changes of pressure are not in themselves sufficient to cause hemorrhage, but in the small veins and capillaries marked disturbances of pressure may lead to rupture. Diapedesis is caused by an increased permeability of the vessel-wall in association with a rise of pressure in the veins. Passive hyperemia, stasis, mechanical, thermal, and chemical lesions of the walls, disturbances of nutrition, etc., may all lead to diapedesis. Neurotic diapedesis also occurs in connection with disturbances of the vasomotor system, arising from the central nervous system, lesion of the conducting nerve fibers, or reflexly. Vicarious menstruation, stigmatization, etc., are to be included in this class. A tendency to hemorrhage is called hemophilia; this may be either congenital or acquired. The former is an inherited condition, the pathology of which is unknown. Acquired hemophilia occurs in all forms of severe infections, in the various purpuras, in disease of the blood, in many intoxications, etc. The sequelæ of hemorrhage are anemia which is directly proportionate to the amount of blood lost, absorption or organization of the extravasate, formation of hematoidin and hemosiderin from the broken-down hemoglobin, etc.

III. Disturbances of the Lymphatic Circulation.—1. *Edema.*—The fluid of the tissues (lymph) is essentially a secretion of the cells of the blood-vessel walls. When the amount of this fluid is increased to an abnormal degree so that the tissue spaces are overfilled with it, the resulting condition is known as edema (dropsy, hydrops). This pathological increase of the lymph is in all cases chiefly due to an increased activity of the secretory cells of the vessels. This is shown by the fact that the fluid of edema contains less albumin and frequently more extractives than the blood, that its chemical nature in different portions of the body differs, and that its production is under nervous control. Further, the specific function of the capillary walls may be excited by injection of certain substances, hypnotic suggestion, etc. The accumulation of the vascular secretion in the tissues may be due to arterial congestion, stagnation of the blood stream, obstruction to the outflow of lymph, pathological alterations in the walls of the capillaries altering their secretion, and stimulation of the vascular secretion by decrease of the pressure external to the vessels (*edema ex vacuo*). Under ordinary conditions neither stagnation of the blood nor obstruction to the outflow of lymph is sufficient in itself to cause edema; but in the first case it is probable that the high pressure stimulates the vessel-walls to increased activity. The pathological changes in the walls of the capillaries and veins leading to increased vascular secretion may be either toxic, infectious, mechanical, thermal, nutritional, or nervous in origin. Clinically the following varieties of edema are described: stagnation, inflammatory, hydremic, cachectic, and neuropathic. The fluid of inflammatory edema contains more albumin, and is probably partly derived from the direct escape of the blood constituents. It may be collateral, occurring in the neighborhood of inflammations.

Hydremia only favors the production of edema, but does not in itself cause it. The edema of nephritis is more probably due to the changes in the vessel-walls, caused by the alterations in the blood. The edema of anemia may be explained in the same way. Edema ex vacuo occurs chiefly in the central nervous system following a loss of a part of the nerve tissue. The local defect becomes filled with fluid resembling in character that of the cerebrospinal fluid. It is produced by an increased secretion from the capillaries which is probably caused by the decreased pressure around the vessels. Edematous tissue is swollen, boggy, inelastic, and pits when pressed upon by the finger. Extensive edema of the skin and subcutaneous tissues is known as anasarca or hyposarca. When the condition is very extreme, rupture of the skin may take place and the fluid escape. Incision or trocar puncture may be of service in allowing escape of the fluid. Collections of fluid in the thorax (hydrothorax) and peritoneal cavity (ascites) may be removed by tapping.

2. *Lymphorrhagia.*—The lymphatic circulation through the thoracic duct or larger lymph vessels may be obstructed by pressure from tumors, inflammations, invasion of lumen by new growths, etc. Local edemas may result, but this is not always the case even when the thoracic duct is obstructed, as the lymph vessels have elaborate anastomoses, and collateral channels may be opened which suffice to carry off the excess of the lymph. Obstruction of large lymph trunks will, however, increase an edema already resulting from excessive vascular secretion. Escape of lymph (lymphorrhagia) is caused by interruption of the continuity of a large lymphatic. Since the pressure in the lymphatic circulation is practically the same as that of the tissues, lymphorrhagia can take place only from a surface, either externally or in a body cavity. The escape may be checked by very slight pressure. Rupture of the thoracic duct is the most important and dangerous. It is usually traumatic in origin, but may be the result of inflammatory processes involving the duct, or it may be caused by obstruction or compression of the duct by tumors. As a result of such a lesion lymph may be poured out into the thoracic or abdominal cavity (chylous hydrothorax, chylous ascites, etc.). If the opening in the lymphatic vessel is permanent, a lymph fistula may result from which there is a permanent oozing of lymph. In this way large quantities of fluid may be lost and serious disturbances of nutrition may result.

Chyle may also appear in the urine as a result of obstruction of the abdominal lymphatics, which in turn leads to dilatation of the lymphatics of the bladder-wall. From the rupture of the latter chyle escapes and becomes mingled with the urine. Chyluria is associated with the presence of the *Filaria sanguinis*, but the exact relations between the parasite and the changes leading to chyluria have not as yet been satisfactorily cleared up. Metastasis of tumor cells, microorganisms, etc., also takes place through the lymph channels (lymphogenous metastasis), and may be either direct or retrograde. The latter plays a very important rôle in the metastasis of carcinoma.

(See *Coagulation, Embolism, Hemorrhage, Edema, Thrombosis.*)

Aldred Scott Warthin.

**Circumcision.**—*Synonym:* Posthectomy. Circumcision is the partial or complete removal of the prepuce or foreskin. The operation is performed as a religious rite, and as a hygienic or therapeutic measure in congenital or acquired phimosis and in some other diseases of the prepuce and penis. Among females in Arabia, Egypt, Nubia, and some other portions of Asia and Africa, travellers have observed a similar custom, consisting of amputation of the labia minora or mutilation of the clitoris.

As a religious rite, circumcision is a practice of great antiquity and geographical extent. While most commonly performed among the Hebrews and Arabians, it is frequently observed by travellers in other portions of Asia and Africa where the origin of the custom is easily traced, and it is also seen in parts of South America, in the islands of the Pacific Ocean, in Madagascar, and in other places where no clue to its origin has yet been discovered. The Hebrews are supposed to have derived their knowledge of circumcision from the Arabians or Egyptians, most probably the latter, among whom the practice originated, according to Herodotus. An interesting account of the operation as performed in Algiers is given by Tarneau, in the *Gazette des Hôpitaux*, 1855, and referred to by Hamdy in his monograph on circumcision, which also gives much valuable information of the history of the operation. The age at which the operation is performed varies in different places. The Hebrews operate on the eighth day, as is also done in Algiers, while generally the Arabians wait until the tenth or thirteenth year, the age of puberty. The operation consists essentially of three parts: circular section of the extremity of the prepuce, tearing of the remainder of the prepuce to the corona and denudation of the glans, and suction of the wound and penis by the operator. Hemorrhage is arrested by styptics, powdered coral, or generally tannin; and simple dressings are applied to prevent the inner layer of the prepuce from again covering the glans penis. As the operation has too frequently been performed by unskilful and dirty hands, serious complications and fatal results have often followed. Cases of death from excessive hemorrhage and inflammation can be found in the literature of the operation, as well as cases of various untoward complications, for example, wounds of the glans penis or urethra. Much has been said, too, of the danger of transmission of syphilis in the third part of the operation, whether from the operator to the patient, or occasionally from the patient to the operator, and numerous cases are upon record in which not only syphilis, but tuberculosis has been transmitted to infants in this manner. These episodes may occur in the form of petty epidemics. Tuberculosis as thus conveyed usually proves rapidly fatal from general infection.

The prepuce consists of two folds of integument, separated by very loose connective tissue, that cover and protect the glans penis. They meet and become continuous at the preputial orifice or end of the foreskin, which is usually the narrowest part of the prepuce, although sufficiently large in adults to allow the prepuce to be retracted so as to expose the glans. At birth the prepuce is longer than the penis, and its orifice narrow, often preventing exposure of the glans, so that a greater or lesser degree of congenital phimosis is pretty constant. The inner surface of the prepuce at this time embraces the glans closely, especially at the corona where there is generally a little circle of adhesions. Sometimes the prepuce and penis are adherent over a much greater extent of surface, either in little patches at various parts of the glans, or from the corona to the meatus. The adhesions are generally easy to subdue, partaking more of the nature of agglutinations than of firmly organized tissue. They are apt to be the source of local irritation, and to cause the retention of the secretion of the glands of Tyson, or smegma præputii. It occasionally happens that the prepuce is imperforate, a condition that soon makes itself manifest and is easily recognized. The child passes no urine, and a soft, fluctuating, transparent tumor forms slowly on the penis. As the tumor grows it pulls upon the skin of the scrotum and pubes, and an inspection shows that there is no preputial orifice. An incision must be made as soon as possible to allow the escape of urine, but circumcision had better be deferred to a later period, when it may be unnecessary to do more than trim up unsightly flaps. In childhood there are not many changes in the prepuce; the few erections rupture a part of the congenital adhesions. Attacks of balanitis or posthitis may result from the decomposition of retained smegma and give rise to contraction of the preputial orifice, or new adhesions between the prepuce and the glans. A child with phimosis and an unhealthy local condition may have no symptoms, and at puberty, with the changes that occur in the penis, the phimosis may disappear. But if there are dysuria or reflex symptoms arising from the phimosis, operative interference is essential, not only to relieve the immediate trouble, but as a prophylactic against various conditions apparently dependent on it, as varicocele, hernia, some cases of masturbation, etc. (see article *Phimosis*). At puberty the glans increases in size, erections become more frequent and strong, and usually destroy any remaining adhesions, while they dilate the preputial orifice so that the phimosis disappears. If any adhesions still persist they are strong and firm, and may prevent the development of the glans, and be the cause of painful erections, tenderness of the penis, etc., as well as of other symptoms more or less evidently dependent on the local condition. Such a condition is best remedied by circumcision, and, indeed, it is a question of considerable interest and importance whether it is not desirable to perform circumcision at an early age as a hygienic and prophylactic measure. The outer lamella of the prepuce is continuous near the corona glandis with the integument that covers the body of the penis. One should remember the elasticity of this integument and the laxity of its subcutaneous tissue, and avoid undue traction upon it in performing circumcision, or it may happen that when the skin has been drawn forward and amputated, an unexpectedly large surface of the prepuce will be found denuded, or there may be a circular wound near the middle of the penis while the parts covering the glans have entirely escaped the knife. Such an accident is usually a surprise to the operator, and may be followed by disagreeable deformities from subsequent cicatricial contraction. Under the circumstances, the best course to pursue is to relieve the phimosis for which the operation has been undertaken, by a dorsal incision, without removing any more integument, and after careful arrest of hemorrhage to approximate the edges of the circular wound as well as possible by sutures and endeavor to secure primary union. The inner surface of the prepuce is reflected forward from the corona glandis to the orifice of the foreskin. In its ordinary condition, protected from friction, and lubricated by the natural secretions of the part, it is soft, pliable, moist, and so much resembles a mucous surface that it is usually referred to as the "mucous membrane," in distinction from the "skin" or outer layer of the prepuce. This layer, and not the skin, is usually affected in phimosis. The constriction is usually at the meatus, although it may be anywhere between there and the corona. The frenum preputialis is a small triangular fold of the inner layer of the prepuce, is inserted near the meatus of the urethra, and when too short may interfere with retraction of the prepuce, pulling the penis downward and producing pain. On each side of it, near the median line, are the arteries of the frenum. When these are divided in circumcision they may be the source of troublesome hemorrhage; accordingly the operator is directed in most of

the text-books to avoid them if possible. When the frenum is short, it is better to disregard this precept and divide the frenum thoroughly, or remove a portion of it, and be prepared to place fine catgut ligatures on the arteries that bleed.

A considerable number of operative procedures have been suggested and practised by different surgeons, having in view the more accurate removal of the redundant prepuce, and the coaptation of the wound surfaces. They fall into three classes: preliminary incision of the prepuce, dilatation, and amputation of the prepuce without previous incision or dilatation. The preliminary incision is usually made on the dorsum of the prepuce, as far back as the corona, and the two flaps thus formed are carefully trimmed away. The incision may be made with a pair of blunt-pointed scissors or a bistoury. The bistoury may be inserted into the preputial orifice on a director, or the point may be protected by a little lump of wax and the bistoury passed with the side to the glans as far as the corona, then, turning the back to the glans, the point is pushed through the foreskin, which is divided by drawing the bistoury forward. The trimming of the flaps may be facilitated by the use of curved forceps applied so as to leave out the portion that is to be removed. Instead of making this division the prepuce may be dilated and cotton stuffed between it and the glans, but this is a tedious and sometimes impossible process, and has no advantages beyond the greater facility of applying needles and sutures in the prepuce, so as to render the coaptation of the surfaces more accurate. The incision, however, is of great value, especially where there is reason to believe that a constricted prepuce conceals a venereal sore that cannot be disinfected. Here a comparatively small incision allows the sore to be exposed, and after it has been disinfected or has cicatrized, the unsightly flaps may be trimmed off. In such cases it often happens that so much tissue has been destroyed by the ulcerative process that there is no excess of tissue when the wound has healed. The most simple and rapid method of circumcision is by a transverse incision made obliquely from behind forward and above downward, in the direction of the margin of the corona glandis, the glans being carefully protected from the cutting instrument. The prepuce may be drawn forward with the fingers or with forceps, and the glans may be protected by Ricord's forceps or the handles of a pair of scissors or other instrument applied obliquely. To insure division of the prepuce at the proper place, if the eye cannot be trusted, it is well to mark with ink or iodine on the prepuce at the point where the corona glandis underlies in a natural condition of the parts, and to make the section a very little in front of this level. Ricord made the mark two lines from the corona, and after applying forceps transfixed the prepuce with needles along the line so as to secure accurate apposition of the two preputial layers after removing the prepuce. Other surgeons, however, sometimes remove more or less of the two layers. Dieffenbach and Redreau removed all the mucous surface, leaving enough of the outer to cover partially the glans. After the prepuce has been drawn forward and divided, the forceps or other protecting instrument is removed, and the integument slides back on the penis, while the inner layer of the prepuce still covers the glans. This may either be turned back if there is no constriction, or divided as far as the corona by cutting or tearing on the dorsum. The two flaps thus formed may be left or trimmed away; it is generally preferable, with a pair of curved scissors and forceps, to cut away evenly on all sides, leaving about a quarter of an inch. At the same time that this layer is turned back any adhesions are carefully broken, or if firm, cut through, doing as little damage to the penis as possible. All hemorrhage should be carefully arrested, fine catgut ligatures being used for the purpose. The edges of the two layers are then united by fine sutures, which may be of either horsehair, silk, or catgut. A continuous catgut suture is very useful, but if many stitches are used there is apt to be considerable swelling of the parts from the contusion and handling. In young children it is not necessary to use sutures, as the dressing prevents the inner layer from again covering the glans, and retains the parts in sufficiently close apposition for union to take place readily. If silk or horsehair sutures are used they should be removed on the fourth day. Instead of sutures, the parts may be held together by serresfines, but these are apt to fall off as the patient recovers from ether and may excite erections. If they are used they should all be removed by the end of twenty-four hours. Before the operation an attempt should be made to disinfect the parts, and antiseptic dressings should be applied. In children it is impossible to prevent the soiling of the wound by urine, but in adults, with care, pretty thorough asepsis may be preserved. After urine has been passed the wound should be thoroughly cleansed with some disinfecting solution and a new dressing applied. In children, cold-water compresses and weak carbolic acid solutions, or a light dressing of iodoformized gauze are as useful as any elaborate dressing, and may be frequently renewed.

The operation should not be performed without some anesthetic. For the surgeon's comfort a general anesthetic is the most satisfactory, but there are many cases in which local anesthesia may well be employed. Cocaine or eucaine may be used, or Schleich's mixture for producing analgesia (see *Anesthesia, Local*). With very young children and when older patients are nervous and emotional, it is not wise to use local analgesia on account of the alarm that is produced by the preparations for and procedures during the operation. On the other hand, in the case of adults, there may be such a complete absence of pain and fright that the patient can himself assist the surgeon in the operation if necessary.

In some cases, especially where there is danger of hemorrhage, the patient suffering from hemophilia, the écraseur, the galvanocautery, or caustics have been substituted for the knife or scissors, but they can hardly be recommended.

The operation is liable to be followed by the ordinary diseases of wounds, but as it is frequently performed by unskilful hands, it has perhaps had more serious sequelæ than other equally simple operations. As already stated, it occasionally happens that too much integument is taken away, in consequence of which there are inflammation and suppuration, and finally a contracted cicatrix. Too little integument is more often removed, and the phimosis returns after cicatrization. The glans penis or urethra may be injured, and severe hemorrhages and deforming cicatrices may result. Occasionally, in tearing adhesions, the glans penis is much damaged, with the same result. Severe inflammation, and even death, may be the consequence. Severe and fatal hemorrhage may occur from small vessels of the prepuce or from arteries of the frenum, or from wounds of the glans penis. From various causes the subsequent inflammation and suppuration may be very severe. Jacobi ("Diphtheria") gives a number of cases in which the wound has been the seat of the diphtheritic process in epidemics of diphtheria, and Hueter ("Chirurgie") mentions fatal cases from phlegmonous erysipelas and gangrene. Gangrene of the penis and retention of urine may also result from tight bandages, or from a thread of circular dressings becoming detached and buried in the swollen tissues at the corona. The latter are exceedingly difficult to discover and remove from the tissues, in which they may sink deeply. Retention of urine is usually reflex, and should be relieved by the use of soft

catheters. Primary union may fail from infection of the wound with chancroidal virus, the infection usually becoming evident about the third day. Free cauterization is necessary, either with the Paquelin cautery or by means of some of the acids. Excessive inflammation or erections may delay the union of the wound. Erections are very common, and in the swollen and tender condition of the part usually very painful. To prevent them it is well to keep the patient on a low diet, and to prevent constipation. Of drugs, bromide of potassium, lupulin, opium suppositories, suppositories or urethral injections of iodoform, camphor, etc., are used. Union may also be prevented by patients who masturbate, so that the inefficiency of the operation as a cure for that trouble becomes very apparent. The edema of the parts on the second or third day after the operation is generally due to rough handling during the operation. The clamp may be applied too tightly, or the parts be much contused in placing numerous sutures.

The indications for the operation are, in children, congenital phimosis when accompanied by hydrocele or hernia, balanitis, preputial calculi, "ballooning" of the prepuce in voiding urine, or by general or special reflex, symptoms, which may depend upon the local condition, as dysuria, convulsions, epilepsy, spasmodic contractions. In adults the operation is indicated for the same set of troubles as in children, and for phimosis dependent upon inflammation, excited by venereal sores, gonorrhea, etc., as well as for simply redundant prepuce without phimosis, when there are any local irritative or reflex symptoms, as spermatorrhea.

The operation should be postponed when the parts are in a condition of acute inflammation, except when there is a sanious discharge from the meatus. In this case, as there is probably a sloughing sore or severe inflammation, the dorsal incision should be first practised to enable local measures to be efficiently applied. The operation should not be done when the patient is known to be a "bleeder," or when very feeble and anemic, or suffering from febrile or severe constitutional disease, unless, indeed, there may be some very urgent symptoms. Here, generally, the complete circumcision should be deferred and the dorsal incision practised.

It is still a mooted point whether hygiene demands circumcision at an early age. It is certain that many cases of varicocele and hernia are due to the straining in micturition and the handling of the penis by young children. In general, however, congenital phimosis does no harm, and disappears at puberty. On the whole, it seems best to await some local disorder or consecutive trouble, and to urge circumcision at the first sign of local irritation, or when general symptoms appear in connection with phimosis.

William G. Le Boutillier.

**Cirrhosis.**—The term cirrhosis (from κιρρός, yellowish) was first applied by Laennec to a yellowish, granular condition of the liver. He wrote of one of his cases, "The liver was reduced to one-third of its original volume. The surface was somewhat granular and wrinkled, and of a grayish-yellow color. Upon section of the organ, there was seen a mass of round and oval granules the size of hemp or millet seeds." In a footnote he added, "This is one variety of those new growths which are grouped together under the term scirrhus. I believe that it should be designated *cirrhosis* because of its color. . . . . This new growth develops also in other organs and finally softens like all other neoplasms." As is now well known, he was in error in believing the condition which he designated "cirrhosis" to be of neoplastic origin.

Although chosen by Laennec as descriptive of the color, the meaning of cirrhosis was soon extended to include the induration which was noted as being a prominent feature in the condition of which he wrote. This idea grew at the expense of the color conception until, in modern usage, the root meaning of the word has been entirely lost and the idea of induration through connective-tissue increase alone remains.

Cirrhosis is a chronic interstitial inflammation characterized by a diffuse hyperplasia of connective tissue and accompanied by hypertrophic, atrophic, or other degenerative changes in the parenchymatous cells. The nature of the degeneration depends upon the organ involved, the chronicity of the process, and the etiological factor.

There is a wide difference of opinion in regard to the application of the term cirrhosis. As first used, it designated only the late stages of what we now know as atrophic cirrhosis of the liver. However, it was very soon extended to include such pathological changes in the spleen and lungs as were characterized by a marked increase in the connective tissue. As the secondary meaning of the word became still more prominent *cirrhosis* became practically synonymous with *sclerosis*, but it is not used in referring to indurative changes in nervous tissue as is the latter. In a general way, cirrhosis means *chronic interstitial inflammation*.

There is also a difference in the significance of the term as it is used by the pathologist and by the clinician. The pathologist includes under cirrhosis all the conditions of diffuse increase in the connective tissue of an organ, but omits all conditions of localized or focal proliferation. Whether or not the increase of connective tissue is sufficient to produce symptoms is not considered. On the other hand, the clinician accepts, in the case of liver changes, any condition as a cirrhosis if the symptomatology is dependent upon connective-tissue proliferation without regard to whether the proliferation is focal, capsular, or what not. There is a growing tendency toward the general adoption of the more strict usage which keeps the meaning of the term within the scope of the definition given above.

When unqualified and when used in speaking of a clinical condition, cirrhosis always refers to *cirrhosis of the liver* (Syns.: cirrhosis hepatis, cirrhosis jecinoris, cirrhosis jecoris, interstitial hepatitis; also named according to its varieties, as atrophic cirrhosis, cirrhosis of Laennec, hypertrophic cirrhosis, cirrhosis carcinomatosa, etc., etc.) For a full consideration of the subject of cirrhosis of the liver, see *Liver, Cirrhosis of the.*

When cirrhosis is used to designate a chronic interstitial inflammation of an organ other than the liver, the name of the organ always precedes or follows. The following are the most important of such terms, and it will be noted that they occur more frequently in the earlier literature than in that of the present day.

*Cirrhosis of the lung, cirrhosis pulmonum*, has been replaced almost entirely by *chronic interstitial pneumonia* (*q.v.*). When the connective-tissue proliferation is dependent upon a tuberculous lymphangitis, especially about the larger bronchi, the condition is spoken of as *cirrhosis pulmonum tuberculosa* (Rindfleisch).

*Cirrhosis of the kidney, cirrhosis renum*, is the same as chronic interstitial nephritis. See *Nephritis.*

*Cirrhosis cordis, cirrhosis of the heart*, must not be confused with *cardiac cirrhosis.* The former is the connective-tissue increase of a chronic interstitial myocarditis (*q.v*). On the other hand, by the latter term there is often designated that form of chronic passive congestion of the liver which is characterized by connective-tissue proliferation aboutthe sublobular and central veins. See *Liver.*

*Cirrhosis of the spleen* is sometimes used to indicate a chronic splenitis with connective-tissue increase, now more commonly spoken of by such descriptive

terms as fibrous induration of the spleen or simply indurative splenitis. See *Spleen.*

Still more rarely used are *cirrhosis of the ovary* for chronic oophoritis; *cirrhosis of the stomach* or *cirrhosis ventriculi* for chronic interstitial gastritis; *muscular cirrhosis* for the chronic interstitial myositis found in old cases of muscular contracture; *turbinated cirrhosis* for the shriveled condition of the turbinates found in some cases of chronic atrophic rhinitis; *cirrhosis peritonei* for the marked degree of chronic adhesive peritonitis often termed peritonitis deformans. For each of these see the description of the pathological changes under the organ in question.

In a general way, the etiology of cirrhosis is to be sought in chronic infections or chronic intoxications. Syphilis and alcohol are the most common factors. Other agents such as malaria, lead, phosphorus, intestinal autointoxications, and acute infections are operative in special cases and are considered under the titles of the various organs involved.

CARL VERNON WELLER.

**Citral.**—($C_{10}H_{16}O$). This is the active constituent of oil of lemon, which contains 7.5 per cent., more than any other oil, though it is found in other fruits of that family and in many other volatile oils of widely different botanical origin. It is a liquid of a yellow color and a specific gravity of about 0.899. It is subject to the same uses as oil of lemon, and may be advantageously substituted for it, in doses about one-tenth as great.

HENRY H. RUSBY.

**Citric Acid.**—Citric acid, $C_3H_4.OH.(COOH)_3+H_2O$, is the agreeably flavored acid of lemons and limes, and occurs also in other fruits, such as the cranberry, currant, strawberry, and raspberry. It is official in the United States Pharmacopœia as *Acidum Citricum*, Citric Acid, and occurs in "colorless, translucent, right-rhombic prisms; odorless; having an agreeable, purely acid taste; efflorescent in warm air, and deliquescent when exposed to moist air. Soluble in 0.54 part of water, and in 1.55 parts of alcohol at 25° C. (77° F.); in about 0.4 part of boiling water, and in 1.43 parts of boiling alcohol, also soluble in 18 parts of ether." (U. S. P.) On heating, citric acid loses its water of crystallization and melts.

Citric acid is the most agreeably flavored of the sour so-called organic acids, and makes, in aqueous solution, a grateful artificial lemon juice. In concentrated solution the acid is irritant, but not corrosive nor specifically poisonous. A six-per-cent. solution of citric acid in water about equals in strength good lemon juice, and if, before solution, a drop or two of the essential oil of lemon be triturated with the crystals, the imitation of genuine lemonade flavor will be quite perfect. Such artificial lemonade can be drunk with the same freedom as the natural article. Taken continuously, and in excess, as in the overfree use of lemons in the tropics, citric acid is capable of producing a peculiarly severe and obstinate form of dyspepsia. The dose is seven and a half grains (0.5). It makes a useful and pleasant refrigerant drink in fevers; it is also used in cases of scurvy, both as a prophylactic and curative agent.

Pharmaceutically, citric acid is of service in the preparation of soluble salts of a number of substances, such as bismuth, iron, quinine, and strychnine. Its principal use is perhaps in the making of the preparations of magnesium citrate.

EDWARD CURTIS.
R. J. E. SCOTT.

**Citronella.**—*Nard-Grass. Andropogon nardus* L. (fam. *Gramineæ*). This is a coarse, tufted grass of India, having a delightful lemon-like fragrance. It is used for the distillation of *citronella oil* or *verbena oil.* This is of a very pale yellow color, often greenish from the presence of copper, and having a specific gravity of about 0.895. It consists of citral and a terpene, and is used altogether in perfumery and flavoring.

HENRY H. RUSBY.

**Citrophen.** — $C_3H_4OH\left(\begin{matrix}CO.NH\\O.C_2H_5\end{matrix}>C_6H_4\right)_3+3H_2O$.

This is a compound of paraphenetidin and citric acid, and occurs as a fine white crystalline powder, soluble in about forty parts of water. It is used in the place of phenacetin, and is of uncertain toxicity and value. Certainly, symptoms of poisoning have followed its use in many instances; but it has been used as an antipyretic, analgesic, for headaches, whooping cough, neuralgias. It is best administered in cachets or in a solution (two per cent.). The dose is eight grains (0.5), which may be repeated two or three times daily; not more than 60 grains (4.0) should be given in a day.

R. J. E. SCOTT.

**Citrus.**—(*The Orange and Lemon Genus.*) A genus of the family *Aurantiaceæ*, if this be held distinct from the *Rutaceæ*, regarded by Engler as comprising but six species, natives of Southeastern Asia and the neighboring islands, but through long and wide cultivation presenting a great number of varieties and forms which have been regarded as species by various other authors. The great economic value of the edible fruits yielded requires no discussion. The following derivations are accepted by Lyons ("Plant-Names, Scientific and Popular") and are probably correctly judged.

The sweet orange from *C. aurantium* L.

The bitter orange from *C. amara* (L). Lyons.

The lemon, both sweet and sour, together with sweet and sour limes and the citron fruit, from *C. medica* L.; although many authors call the lemon *C. limonium* Risso, the sweet lime *C. limetta* Risso, the sour lime *C. acida* Pers., and the citron fruit *C. cedra* Gallesio.

The mandarin or tangerine from *C. nobilis* Lour.

The shaddock, grape fruit, or pomelo from *C. decumana* Murray.

The bergamot from *C. bergamia* Risso and Poit probably an artificial hybrid originating under cultivation.

The medicinal importance of the genus is very considerable, although not so great as in the past. The medicinal products of the orange and lemon are considered under the titles *Aurantium* and *Lime.* Only the general characters of the products will be here considered. The medicinal virtues reside in three constituents or classes of them: (1) *Citric Acid*, separately considered; (2) *Bitter Glucosides;* (3) *Volatile Oils.*

The bitter glucosides appear to reside in the inner portions ("white") of the rinds (*aurantiamarin* in oranges, especially the bitter orange, and in citron fruit, and *naringin* in grape fruits or shaddocks) or in the seeds, as *limonin* in the seeds of the lemon. These substances, medicinally, act like ordinary bitters, and like them are irritant and even poisonous in their pure form, especially the naringin of the shaddock.

*Hesperidin*, $C_{22}H_{26}O_{12}$ (*fide* Merck), occurs in minute white or yellowish crystals and is soluble in dilute alkalies. It splits up into glucose and *hesperetin* ($C_{16}H_{14}O_6$).

*Isohesperidin* is very similar.

*Naringin* ($C_{23}H_{26}O_{12}+4H_2O$) is in yellow crystals and is soluble in alcohol and in 300 parts of water.

*Limonin* ($C_{22}H_{26}O_7$?) occurs in minute crystals, and is soluble in alcohol and acetic acid.

Bitter substances also exist in the leaves of these plants, but whether identical with those mentioned above is not known.

The volatile oils in use are derived from the flowers and from the outer portions of the rinds of the fruits. While they possess the ordinary diffusive-stimulant properties of volatile oils in general, they are scarcely used for their medicinal properties, but almost wholly for their flavoring effects. The differences between them pertain almost entirely to the latter uses. Oil of mandarin rind is in use and is practically identical with that of orange. Oil of Bergamot, or Oleum Bergamottæ, is official. It is greenish or greenish-yellow and bitter, with a specific gravity of 0.880 to 0.885, and contains limonene, dipentene, linalool, and linaloyl acetate. There is no official preparation.

Volatile oils also exist in the leaves, but these are not employed.

From the above, it is obvious that the Citrus products can be used as simple bitters, as aromatics, or as aromatic bitters, according to whether the constituents are used separately or in a preparation which combines them.

One of the very best of these bitter tonics is the grape fruit, eaten at the beginning of the breakfast, and not too much care should be taken to avoid entirely the bitter portions.

HENRY H. RUSBY.

**Civet.**—A sienna-brown, ointment-like, unpleasantly odorous substance, obtained from two species of *Viverra;* Order *Carnivora, Viverrina.* The first, *Viverra zibetha* Linn., the Indian civet cat, is from the warmer parts of Asia. The second, *V. civetta* Schreber, the African civet cat, is a native of Africa and Southern Europe, especially of Abyssinia. Both are kept in confinement for their peculiar secretion, which is formed in a sac-like gland, situated in front of the anus, in both sexes. When first gathered, it is semi-liquid and brownish yellow, but by keeping it becomes considerably darker and harder. It is a nasty-smelling and dirty-looking substance, usually mixed with hairs and other impurities, and is mostly packed in horns for export. The odor, while having a general resemblance to that of musk, is less diffusible and far more disagreeable. Civet is insoluble in water and only slightly soluble in alcohol; not wholly so even in warm ether and chloroform. It is now used almost wholly for strengthening and fixing perfumes and for scenting bait for game.

HENRY H. RUSBY.

**Civiale, Jean.**—Born at Thiézac, Cantal, France, in July, 1792. While still a medical student in Paris, in 1817, he chanced to hear a lecture by Marjolin on stone in the bladder, in which mention was made of the instruments invented by Gruithuison for the purpose of breaking the stone into small pieces in the bladder. Civiale was attracted by the idea of avoiding the cutting operation and set out to devise some means of dissolving the stone in the bladder or at least of so reducing its size that it could readily be extracted per vias naturales. Failing in this attempt he devised an instrument for perforating the calculus and then crushing it to a powder. Others, as Amussat and Heurteloup, had previously discussed the possibility of lithotrity, but Civiale was undoubtedly the first to perform the operation on the living subject, which he did before a committee of the Academy of Sciences and a large number of surgeons on January 13, 1824. For this feat two prizes were awarded him—one of the value of 6,000 francs, by the Academy of Sciences in 1826, and another, the Monthyon prize of 10,000 francs, in 1827. From this time he devoted himself wholly to this one operation, becoming thereby one of the first, and the narrowest, of specialists. However, the skill which he acquired in his limited field was very great and his renown brought him an enormous practice and a large fortune, estimated at the time of his death (June 18, 1867) to be several million francs.

Civiale was bitterly assailed by many of his contemporaries and in turn savagely attacked some of the leading surgeons of his day, such as Dupuytren, Jobert, Velpeau, and others, and several of his writings are marred by fierce invectives against his assailants. Among his publications on lithotrity are the following: "Nouvelles considérations sur la rétention d'urine, suivies d'un traité sur les calculs urinaires, sur la manière d'en connaître dans l'intérieur de la vessie, et la possibilité d'en opérer la destruction sans l'opération de la taille," 1823; "De la lithotritie," 1827; "Parallèle des diverses méthodes employées pour guérir les calcules," etc., 1836; "Traité pratique et historique de la lithotritie," 1847.

T. L. S.

**Cladorchis.**—*C. watsoni,* is a name that has been sometimes used for a trematode, or fluke worm, of the genus *Amphistomum.* This parasite has been found in the intestine of a negro in Africa. See *Trematoda.*

A. S. P.

**Cladothrix.**—A genus of higher bacteria, grouped by Migula with a number of more or less unrelated forms in the family *Chlamydobacteriaceæ.* Most bacteriologists of the present day, however, place it among the moulds in the family *Trichomycetes.* It consists of slender rod-shaped cells, forming filamentous false-branching chains or threads. The reproductive cells, gonidia, are motile and bear polar flagella.

T. L. S.

**Clarendon Springs.**—Rutland County, Vermont.

POST-OFFICE.—Clarendon Springs. Hotel and cottages.

ACCESS.—Via Delaware and Hudson Railroad to West Rutland Station; thence three miles to springs. This point is seven hours by rail from New York, five hours from Boston, three hours from Troy and Albany, and two hours from Saratoga.

Clarendon mineral-spring water is from a spring which flows 20,000,000 gallons yearly, and which is located in a beautiful valley among the green hills at a level of 1,000 feet above the sea. This is doubtless one of the oldest resorts in the country, the medicinal character of the water having been discovered by one Asa Smith, it is said, in the year 1776. From 1,500 to 2,500 persons visit the springs annually in pursuit of health and pleasure. Amid the beautiful scenery, pleasant drives, and rare opportunities for trout fishing, the visitor may while away the summer days in a delightful manner. The hotel and cottages are said to be of an excellent character. The following analysis was made by Ricketts and Banks of New York in 1899:

ONE UNITED STATES GALLON CONTAINS:

| Solids. | Grains. |
|---|---|
| Sodium chloride | 0.1458 |
| Potassium sulphate | 0.1155 |
| Calcium sulphate | 0.4054 |
| Calcium bicarbonate | 10.6578 |
| Magnesium chloride | 0.0630 |
| Magnesium bicarbonate | 2.1443 |
| Iron bicarbonate | 0.0692 |
| Silica | 0.6533 |
| Alumina | 0.0466 |

This water, naturally carbonated and mildly aperient, contains as the principal mineral constituents the salts of lime and magnesia which account for its

alkaline character, and to a great extent for its medicinal properties. The water has an unvarying temperature of 47° F.

The baths are open from November to May. There are hot and cold saline and hydroelectric baths; complete electrical baths; and static and sensorial, galvanofaradic currents with hydroelectric douche. Massage in all its branches is available; also the Schott system for heart disease.

The water is beneficial in rheumatism, gout, nervous and digestive disturbances, anemia, obesity, and cutaneous affections, and in kidney and liver disorders.

The water is a very pure and wholesome beverage, independent of its medicinal qualities. It is used commercially EMMA E. WALKER.

**Clark, Alonzo.**—Born in Chester, Mass., on March, 1, 1807. He received the degree of Doctor of Medicine from the College of Physicians and Surgeons, New York City, in 1835. From 1848 to 1855 he was Professor of Physiology and Pathology in this school; but in the latter year the two branches of medical instruction were separated, Dr. Clark being given the Chair of Pathology and Practical Medicine, while that of Physiology was assigned to Dr. John C. Dalton. Dr. Clark continued to perform the duties of his professorship up to the year 1885. During this entire period he was also one of the Visiting Physicians at Bellevue Hospital; and in 1861 he was elected Consulting Physician to St. Luke's Hospital. He died on September 13, 1887.

Dr. Clark will be remembered by many physicians of the present day as a most inspiring teacher of pathology and practical medicine. His most important contributions to therapeutical science related to the employment of opium in large doses in acute peritonitis, and to the open-air treatment of typhus fever. A. H. B.

**Clark, Sir Andrew.**—Born in Aberdeen, Scotland, October 28, 1826. He received the degree of Doctor of Medicine, in 1854, from the Medical School in his

FIG. 1408.—Sir Andrew Clark.

native city. Shortly afterward he succeeded, through the intervention of influential friends, in obtaining the position of Assistant Physician in the London Hospital. In 1858, he was made Lecturer of Physiology, and in 1866 Full Physician, in the same hospital. From this time onward Clark rose rapidly to the position of one of the leading clinicians of London. He also displayed great activity as a writer on medical topics, especially those belonging to the domain of lung and kidney diseases. In 1866 he became the family physician of Mr. Gladstone, who was then on the eve of being made the leader of the Liberal Party in England, and who became one of Clark's warmest personal friends. In 1888 he was elected President of the Royal College of Physicians. During the month of October of the same year he experienced an attack of cerebral apoplexy, from the effects of which he never afterward entirely recovered. He died November 6, 1893, and his death was mourned by the English people generally as a loss to the entire Nation.

Sir Andrew Clark's contributions to medical literature are very numerous. The following are among the more important of his published writings: "On the Anatomy of the Lungs" (in H. Davies' work on "Physical Diagnosis"); "On Tubercular Sputum"; "Evidences of the Arrestment of Phthisis"; "Mucous Diseases of the Colon"; and "Fibroid Phthisis." His predilection for topics in some manner related to tuberculosis is easily explained by the fact that he was himself a subject of this disease during his youth and early manhood. A. H. B.

**Clarke, Jacob Augustus Lockhart.**—Born in London in 1817; studied medicine at Guy's and St. Thomas' Hospitals. While practising as a family physician in Pimlico he devoted much time to the study of the physiology and histology of the nervous system and soon won for himself an enviable reputation. In recognition of his work in this field he received the gold medal of the Royal Society in 1864; in 1867 he was elected an honorary fellow of the Royal College of Physicians of Ireland; in 1871 he was appointed physician to the Hospital for Epilepsy and Paralysis, a position which he held to the time of his death on January 25, 1880. He was the first to describe accurately the posterior vesicular column (nucleus dorsalis, BNA) of the spinal cord, commonly called, after him, Clarke's column.

Most of Clarke's writings on the structure and development of the central nervous system appeared in the Philosophical Transactions, in the Proceedings of the Royal Society, and in the British and Foreign Medico-Chirurgical Review; his articles on the pathology of the nervous system, epilepsy, muscular atrophy, etc., were published in the Transactions of the Medico-Chirurgical, Pathological, and Clinical Societies, and in the St. George's Hospital Reports. T. L. S.

**Clarke's Riverside Mineral Springs.**—Wayne County, Michigan.

POST-OFFICE.—Detroit.

This resort is located on Fort West Street, corner of Clark Avenue, about two miles from the center of the city of Detroit. It is reached by electric cars, which pass the door of the bath-house every few minutes. This bathing establishment is one of the most elegant and luxurious to be found in the country. The springs are two in number, and furnish an abundant flow of water. The following is an analysis made by Samuel P. Duffield, M.D., Ph.D.

ONE UNITED STATES GALLON CONTAINS:

| Solids. | Grains. |
|---|---|
| Sodium chloride | 3,408.50 |
| Potassium chloride | .18 |
| Calcium chloride | 860.00 |
| Calcium sulphate | 1,790.98 |
| Magnesium sulphate | 1,082.02 |
| Magnesium carbonate | 11.22 |
| Calcium carbonate | 149.16 |
| Silica | 3.50 |
| Alumina | 13.41 |
| Total | 7,318.97 |

Sulphureted hydrogen gas, 40.76 cubic inches.
Temperature of water, 56° F.

The bath-house is kept open all the year. The waters have been found very useful in the diseases to which the saline-calcic class is applicable.

EMMA E. WALKER.

**Clastothrix.**—This word and its transposition form, trichoclasia, are synonyms very rarely employed of trichorrhexis nodosa and are said to have been introduced into dermatology by Sir Erasmus Wilson in 1849. Since their significance is "broken hair" (κλαστός, broken up, and θρίξ, hair) these terms should be equally applicable to all forms of brittleness and hence be synonymous with atrophia pilorum propria, (which see). See also the article on *Tricorrhexis Nodosa*. Since the termination -thrix is of common use to characterize certain thread-like microorganisms the employment of the word clastothrix for an affection of the hair should be discontinued. E. P.

**Claudication, Diagnostic Significance of.**—See *Limping*.

**Claudication, Intermittent.**—Intermittent claudication, or intermittent limping, is the name given to a set of symptoms caused by a diseased condition of the blood-vessels and manifesting itself by temporary interference with the active movements of the parts of the body involved and accompanied during these periods with pain and at times cramping.

In the first descriptions of the disease reference was made only to such cases in which the lower extremities were affected, but following, these early publications similar involvements of almost all the muscle groups have been recorded.

Charcot was the first to call attention to this condition (1858) calling the syndrome painful intermittent paralysis (paralysie douloureuse intermittente). His case revealed, at autopsy, an aneurysm of the right iliac artery with further downward occlusion by a thrombus. He referred also to the condition known as springhalt, occurring in horses, and described by Bouley (1831). In the animals so affected, sclerosis and calcification of the iliac arteries and of their bifurcations from the aorta were constant findings. Charcot wrote several later articles on intermittent claudication, as did other French writers (Sabourin, Delaunay, Magrez, Bourgeois).

With the exception of the French investigators not much attention was devoted to this subject till two Germans, Elzholz (1892) and Goldflam (1895), recognized the disease and recorded cases.

Erb (1898) took up the consideration of the condition in greater detail, including in his work a thorough review and analysis of the literature and some valuable original observations. More recently a large number of contributions have been made by both German (Higier, Hagelstam, Nothnagel, Wandel) and American writers (Putnam, Dana, Riesman, Burr, Hunt). Putnam was the first to describe the occurrence of the disease in America.

Other less commonly used names for this affection are: intermittent muscular paralysis (Grossman), dysbasia angiosclerotica intermittens (Erb); myasthenia angiosclerotica (Higier); angina cruris (Walton and Paul); and dyspragia intermittens (Ortner). Of these, intermittent claudication and dysbasia angiosclerotica intermittens are the best known and most appropriate.

ETIOLOGY.—The causes of intermittent claudication are divided by some writers into predisposing and exciting, primary and secondary, or active and contributory, but such classification is difficult to follow definitely.

The disease is a result of defective nutrition of the musculature of the affected limbs, this in turn being due to a diseased condition of the arterial walls, interfering with their normal blood flow. Any factor leading to arteriosclerosis will tend to bring on the affection. Most cases occur after the age of forty and more men are affected than women.

Tobacco has been particularly condemned by Erb and v. Frankl-Hochwart as a cause of arterial changes, and Erb, in a number of his cases, found it to be the most probable exciting agent; in some the excessive use or abuse of tobacco was the only obtainable cause. He considers the use of tobacco vastly more likely to lead to arteriosclerosis than the use of alcohol. The tobacco theory would lead one to expect the largest number of cases of intermittent claudication to be found among the greatest tobacco-consuming nations but so far such statistics have not been worked out satisfactorily.

Syphilis is without doubt the most active of all the known causes of arterial changes and provokes a form of sclerosis characterized by an intense intimal overgrowth with a consequent greater comparative narrowing of the lumen.

Exposure to excessive cold is a contributory and sometimes an active cause, and infections may aid in bringing on the symptoms, perhaps by causing an acute disease of the arteries.

Certain occupations, by constant pressure or exposure may be contributing factors to the etiology. The exposure of the feet and ankles, being as a rule greater than other parts of the body, probably has a great deal to do with the more frequent involvement of the anterior and posterior tibial arteries. The tendency of the blood to be more stagnant in these most distal arteries would give any toxin in the blood a greater chance of affecting the vessel walls.

Occupations wherein the hands and arms are constantly exposed to intense cold or excessive vibration are quite frequent causes of the affection in the upper limbs. Reference has been made (Williams) to such cases occurring in marble cutters using the pneumatic chisel and no doubt other similar mechanical devices causing marked vibration would have the same effect upon their users.

A great deal of importance has been attributed by Oppenheim to the neurotic element, the neuropathic diathesis, and he recognizes a purely functional type of the disease due to this instability of the vasomotor system. Some writers believe further that this weakness of the cardiovascular system is hereditary.

General toxemic states, such as gout, uremia, rheumatism, and chronic metallic poisoning (lead, mercury, etc.) aid in the bringing on of this disease, and among the toxemic causes one of considerable importance is gastrointestinal intoxication, from the absorption of poisonous fermentative and putrefactive products of the intestinal bacteria. More attention is now being directed to this form of toxemia as a cause of arterial changes.

PATHOLOGY.—The comparatively few autopsies have all shown some form of arterial sclerosis, in several cases accompanied by thrombotic changes. In a few instances (Charcot, Barth, Mannaury) aneurysms were found. In many, overgrowth of the intima was the principal finding, the obliterating endarteritis of Friedländer, while in others a general overgrowth of the entire vessel walls, the periarteritis nodosa of Kussmaul and Maier, was found.

The smaller arteries are usually more affected though frequently the larger vessels such as the femoral and brachial are involved. Extensive thrombosis often occurs with the vascular disease.

Similar, though mostly less marked, pathological alterations have been reported as occurring in the veins, taking the form of an endophlebitis or phlebosclerosis. Such condition of the veins usually, unless very prominent as in Grieg's case, would be only secondary to the arteriosclerosis and not a cause of intermittent claudication.

Burr found acute fatty degenerative changes in the muscles in one of his reported cases. In the more advanced forms of intermittent claudication alterations occur of a secondary nature dependent upon the local ischemia. The muscles become degenerated, atrophied, or even sclerosed (Marinesco). The atrophy may be due to alterations in the nerves caused by the closure of the vasa nervorum. The disease of muscle groups here may give degenerative muscular atrophy of the peripheral nerve type (Joffroy, Achard, Schlesinger). Gangrenous processes of varied intensity may be caused.

The pathology of such cases as are dependent upon what might be called an abnormal irritability of the vasomotor system, causing vasoconstriction with consequent periodic disturbance of function in the parts affected, has not been worked out satisfactorily. Any defect in the structure of the blood-vessels would be unfavorably acted upon by any such undue irritability of the vasomotor apparatus. When the arterial changes are far advanced, the probability of any contraction of the arteries occurring is doubtful, for the contractile fibers have lost the greater part if not all of their power and often are entirely absent (Burr). Mills and Williams recorded a case of spinal pachymeningitis with such a constantly changing variety of symptoms as could only have been caused by sudden alterations in the caliber of the blood-vessels. The autopsy showed an intense degree of arterial thickening throughout the spinal cord.

While most of the chronic arteriosclerotic cases are not due to any periodic contraction of the vessel walls, during the earliest stages of arteritis and in the cases occurring in young people angiospasm may be the principal cause. Good examples of such a complex have been reported by Goldstein and Weisenburg.

Symptomatology.—Usually in a man past middle life, there will be a history of the patient having to stop during walking or working and rest for from ten to twenty minutes. He is then able to resume his efforts, but after a variable period the weakness returns. The earliest signs as a rule are sensory, such as a feeling of weight and heaviness or clumsiness and a sense of not being able to use the legs properly.

Pain usually accompanies these periods of weakness but in most cases does not continue during the intervals of rest. It may, however, be continuous and so severe as to interfere seriously with the patient's rest, but even then the pain is materially increased during the paroxysms.

Cramping of the affected muscles with whiteness and numbness of the limbs may accompany the temporary paralysis, or the limb may be somewhat swollen and cyanotic.

The patient frequently notices a feeling of numbness creeping over his limbs or some peculiar form of abnormal sensation such as of bursting water or of water gushing into the legs, or of drops of liquid running underneath the skin and suddenly breaking through, or a dull sickening ache very difficult to describe definitely. The forms of perverted sensation may be the only symptoms for quite a while and they may be so severe as to necessitate the patient resting before any motor disturbances manifest themselves. Often in senile cases numbness, tingling, and cramping pains are for a long time the only evidences of arterial disease.

Palpation of the dorsal arteries of the feet and the posterior tibials in more advanced cases, shows absence of the pulsation. This sign is very constant in the dorsalis pedis artery. The femoral and brachial arteries, more often the former, will frequently be found not pulsating or thickly sclerosed with the pulsations very weak.

Arteriosclerosis is usually general but may not be noticeable except in the affected limbs. The occurrence of a severer degree of arteriosclerosis in one arm or leg than in the other is not an uncommon finding and intermittent claudication though mostly bilateral is often much more advanced on one side.

The legs are congested and swollen, cold and cyanotic, in general the signs of poor vascular tone. The white appearance is found more commonly in the upper limb form.

The *upper limb type* of intermittent claudication occurs either as an independent complex or in conjunction with affection of the lower limbs. Frequently too in these cases the muscles of the shoulders and even of the face and tongue are simultaneously involved (Goldstein, Goldflam, and others).

In women the arms are more often involved than the legs, due most likely to the comparatively greater use and exposure of the arms in women so affected (short sleeves, scrubbing, washing, etc.). The history of overuse of the arms in scrubbing and washing, particularly during cold weather, or in men of the use of vibratory machinery, will aid in forming a diagnosis. The radial pulse is usually absent or decidedly lessened. The brachial too may be diseased and a radiograph will often show the outline of the calcified vessel. The intermittent weakness, numbness, and blanching of the hands, together with the periodic pain, help make certain the diagnosis of the upper limb type of this disease.

A case of Brissaud's in which there was burning pain of an intermittent character along the anterior aspect of the thigh, occurring after about twenty minutes walking, resembled meralgia paresthetica of that part. The autopsy here showed arteriosclerotic changes in the branches of the femoral artery in Scarpa's triangle.

Burr reported sclerosis of the pudendal artery causing incontinence of urine and incontinence of urine and feces were symptoms of the same condition recorded by Luxemburg.

An *intestinal form* with sclerotic changes in the mesenteric arteries has been reported by Schnitzler and Ortner, also changes occurring in kidney, brain, and retina (Wagenmann, Rosenfeld, and Hunt) and of the coronary arteries in angina pectoris (Potain and others). In the retinal type the spasm of the central retinal artery causes pallor of the disc.

A *spinal cord type* has been recorded by Déjerine, and a similar case reported by Reckord where the arteries of the cord becoming affected caused intermittent loss of motor function, increased tendon reflexes, ankle clonus, and positive Babinski. These symptoms were always brought on at intervals by exertion and relieved by rest. The absence of pain and of peripheral circulatory disturbance with the usual occurrence of vesical and rectal involvement aid in distinguishing this type from the peripheral form. Precipitate micturition is considered an important early symptom. The spinal type is more frequent in males and one side is generally more affected than the other. It usually develops into a spastic paraplegia similar to any paraplegia of spinal origin and if first seen at such late stage could not be distinguished.

To be distinguished from the above is the *lumbar type* of intermittent claudication described by Hunt. This syndrome in its individual attacks resembles lumbago—being brought on only by exertion, however, and stopping when the patient is at rest. The intermittent occurrence is here just as characteristic as in the other forms. It is caused by a sclerosis of the arteries of the lumbar muscles.

The *cerebral type* described by Oppenheim, Weisenburg, and others manifests itself as a more or less sudden weakness of the arm or leg or both, generally taking the form of a temporary hemiplegia. During these periods the usual signs of an organic disease of the motor cortex or pyramidal tract are to be found, such as increased reflexes, positive Babinski, loss of motor power and sometimes hypesthesia or anes-

thesia. In Weisenburg's case the attacks occurred on either side, involving the speech when the right side was the one affected. Here there was an epileptic history and a possibility of these periods of weakness being epileptic equivalents. The temporary relief of the paralytic seizures was not dependent upon any drugs administered and the case must be explained on the theory of vasomotor spasm.

Diagnosis.—Typical cases of this malady are unmistakable. In its atypical forms, however, intermittent claudication may be very difficult to differentiate. One such form is illustrated in Burr's case where the vascular disease was added to a hemiplegia forming a well-marked triplegia. Here the characteristic peripheral arterial changes with the absence of the signs of motor tract involvement on that side were the deciding points.

Cases of myasthenia gravis have been mistaken for intermittent claudication, the weakness of the muscles in such cases often resembling that in intermittent claudication. In the latter, however, pain is almost always a prominent symptom and the characteristic arterial findings are not present in myasthenia gravis.

Tumors of the pelvis by pressure upon the intrapelvic arteries sometimes give a very confusing symptom complex. Usually the pain extends along the nerve distributions affected by the intrapelvic growth, and the presence of corresponding areas of numbness or of hyperesthesia is of value in the diagnosis. The effects of circulatory interference from pelvic tumors are also more constant and the coldness and numbness and other symptoms will not entirely disappear even during the least aggravated periods. Radiography is of importance in the diagnosis of this condition.

In considering the cerebral types migraine should be recognized as a possibility of confusion. This is particularly true of cases in which the patient is subject to attacks of partial or complete hemiplegia lasting for variable lengths of time. Here as in the transient paralytic equivalents of epilepsy the vasomotor system is most likely the cause. Similar temporary paralyses occur in toxemic conditions from gout and nephritis, also, in all likelihood, of vascular origin.

Raynaud's disease and erythromelalgia are vascular in type and bear a close relation to intermittent claudication, though some writers consider them to be primarily due to nerve affection.

Prognosis.—The outcome in these cases is dependent upon the underlying cause and the extent of the arteriosclerosis. Where syphilis is the essential cause considerable improvement may be expected under antisyphilitic treatment. Advanced cases can only be checked in some degree, as a gradual increase in severity is bound to occur in most of them.

In the acute forms favorable results may often be obtained by the proper management.

Treatment.—In acute cases, such as those following infectious diseases or very severe exposure to cold and wet, the patient should be kept warm and the affected limbs should be covered with dry cotton dressing, care being taken to have the bandage loose enough to avoid any interference with the circulation. Light massage daily and the use of warm baths or of cloths wet in warm water are beneficial. Excessively hot or cold baths or applications are injurious. Constitutional treatment should be instituted early, particularly where the cause is such as can be combated dietetically and medicinally. In syphilitic cases mercurial inunctions and injections should be given according to the usual antisyphilitic treatment.

In chronic cases the prognosis is not good but the outlined treatment may palliate the condition somewhat. Electricity in the form of mild galvanic applications or electric baths will sometimes prove of benefit. Drugs acting directly upon the condition are of doubtful value. Potassium iodide and nitroglycerin have been found to give the best results, but their effect is only temporary. A change of occupation may be necessary in some cases.

Edward Mercur Williams.

**Clavicle, Surgery of the.**—The clavicle may be congenitally absent or partially defective. It may be deformed in rickets and osteomalacia, or as a consequence of badly united fracture. Fracture of this bone may occur *in utero*.

*Diseases* of the clavicle are rare. The principal ones noted are syphilis (gumma), tuberculosis, and osteomyelitis; with resulting periostitis, osteitis, abscess, caries, or necrosis. Syphilis is said to be quite frequent as a tertiary manifestation (at the external end). Tuberculosis is very rare, while acute osteomyelitis is not exactly rare if we bear in mind that the clavicle, being a short bone, is not predisposed to it.

*Neoplasms* of the clavicle are seldom met with. The form of new growth most often seen is some variety of sarcoma. Carcinoma is much more rare and its occurrence as a primary growth appears somewhat doubtful. Osteomata (exostoses) and enchondromata are seldom reported.

*Traumatism* may cause contusions, wounds, fractures, or dislocations. Wounds and contusions require no special mention. (See the articles on *Fractures* and *Dislocations*.)

The diseases and neoplasms of the clavicle present no clinical features peculiar to this bone. In syphilis, *treatment* with mercury and iodide of potassium should be thorough, and if portions of bone die they should be removed. Tuberculosis is apt to begin here in the periosteum, and the sharp spoon should be employed to remove the foci as thoroughly as possible, especially if suppuration threatens or actually takes place. When suppurative osteomyelitis is recognized, an incision should be made over the affected area, and after raising the periosteum the affected portion of bone should be chiselled or scooped away and the resulting cavity drained. Abscess, as elsewhere, requires incision and drainage and the removal of any dead bone. Since several of the previous affections cause necrosis or osteitis, the therapeutic procedures are to some degree common to all. These are chiefly partial or total excision. Tubercle alone may perhaps be cured by simple treatment limited to the lesion, as in the case of other tuberculous foci.

Compound fractures, particularly if caused by pistol or rifle balls, require a thorough examination and disinfection under an anesthetic. One may decide also to keep the fragments in apposition by sutures, or to excise the whole or a part of the clavicle. The question of suturing simple fractures of the clavicle is still unsettled. When there is marked deformity, and particularly when sharp fragments appear likely to cause damage to important vessels or nerves in their neighborhood, the operation has some warm advocates.

The principal *operative procedures* on the clavicle are *suturing*, or wiring, for fracture or dislocation; *curetting*, for tuberculous or syphilitic foci; *incision*, chiselling, etc., for osteomyelitis or removal of necrotic fragments; *excision* of the clavicle, partial or total; and temporary *resection*. The formation of a *clavicular pseudarthrosis*, for the relief of ankylosis of the scapulohumeral articulation, has been suggested by Tillaux.

*Excision of the clavicle*, whether partial or total, may be done beneath the periosteum or outside it. The operation, whether total or partial, varies somewhat with the cause, the typical resection being that

practiced for necrosis or caries, while the many performed for malignancy naturally vary with the case. Nearly half the cases of total extirpation of the clavicle collected by Norkus were for necrosis or caries. When operating for these diseases, for fractures, or for benign new growths, the subperiosteal method should be employed. Where it has been made use of, restoration of the bone has taken place to a considerable extent or has been complete in the majority of cases, and the functional result has been excellent or perfect, while in some there has been no apparent deformity. An incision is made from one end of the clavicle to the other, extending through the periosteum, which is then detached from the bone with an elevator. The clavicle is then disarticulated at either extremity first, as may be most convenient; or it is divided at some intermediate portion and the two extremities are separately released from their attachments and removed. Care is to be exercised not to injure the large vessels adjacent to the sternoclavicular articulation. It may be necessary to prolong the incision beyond either joint, or to make smaller transverse incisions at either extremity of the wound in order to gain better access to the articulations. When the disease process has separated the bone from the periosteum, it may be possible to extract it through a fistulous tract, or through a small incision dividing the skin and periosteum at a suitable point. Partial excision of the clavicle, removing more or less of the outer or inner extremity or a portion of the middle of the clavicle, may be performed for non-malignant diseases of the clavicle. For sarcoma and other malignant new growths, neither the partial nor the subperiosteal method should be resorted to. In the thirty-two cases of extirpation of the clavicle for tumors (sarcomata in twenty-four instances) collected by Norkus, six deaths from the operation resulted. The incision is the same as in the subperiosteal operation. The cutting must always be done toward the periosteum, the attachments of the muscles should be carefully severed from it, and the bone should be removed either in fragments after cutting or sawing through it, or as a whole, including the new growth. The wound is to be closed by suture after the divided sternocleido-mastoid and trapezius above have been carefully united by deep sutures to the pectoralis major and deltoid muscles below.

The high primary mortality which still attends total excision for malignant disease (chiefly sarcoma) dissuades some surgeons from performing it, especially as the ultimate outlook is poor. The statistics usually quoted are, however, rather antiquated.

Madelung advocates *temporary resection of the clavicle* to give access to the subclavicular region. He recommends the division of the clavicle in its inner third, together with the subclavian and both pectoral muscles, in order to separate widely the divided ends of the clavicle. This gives free access to the subclavicular space and even to the axilla. The clavicle is divided obliquely from above and within downward and outward, in order that the subsequent adaptation of the parts, when the wound is closed, may be more perfectly secured. The pull of the sternocleidomastoid muscle and the weight of the arm are better opposed by the adoption of this plan than if we resort to the straight backward division of the clavicle.

The operation is proposed for the purposes of gaining access to the subclavicular nerves and blood-vessels, of extirpating subclavicular and axillary neoplasms, of attacking diseases of the upper ribs, and of reaching the apices of the pleuræ or lungs.

William G. Le Boutillier.

**Clavus.**—A corn (clavus) is, as a matter of fact, a small circumscribed callus of an inverted conical shape.

Two varieties of corns are described, namely, the *hard* and the *soft*. The hard corn is usually found upon the dorsal surface of the foot, especially where the foot exercises undue pressure, viz., over the joints of the toes.

The soft corn occurs between the toes, and the horny plug instead of being dry and harsh, as in the first-mentioned variety, is soft and macerated.

Corns are generally painful on pressure and are often regarded as barometers by their unfortunate possessors in indicating changes in the weather.

Corns are occasionally encountered upon the palms and soles.

Suppuration may occur under the corn, and possibly may be the starting-point of inflammatory reactions and even grave infections. As a rule, such accidents are the result of improper manipulations with unclean implements.

The *treatment* of corns consists first of all in the removal of undue pressure exerted by ill-fitting shoes; for otherwise the corn will return again and again even after the most thorough removal.

To remove a corn the parts must be immersed in hot water for twenty or thirty minutes after which the lesion may be pared until level with the surface. The skin is then thoroughly dried, and the region covered with a felt ring, which must be changed daily. Hyde and Montgomery recommend that instead of this ring the seat of the corn and the adjacent skin be covered completely with many narrow, short, and neatly adjusted strips of rubber plaster. This plaster comes off spontaneously in a few days, an oil poultice is applied and the dressing renewed.

So far, however, as operative interference is concerned it is usually advisable to procure the services of a skilful chiropodist if we can be assured that his work will be performed under proper aseptic conditions.

The application of salicylic acid in paint or plaster gives good results. The usual formula for a paint is as follows:

| | | |
|---|---|---|
| Acidi salicylici, | gr. xv–xxx. | (1.0–2.0) |
| Ext. cannabis indicæ, | gr. x. | (0.6) |
| Collodii flexilis, | ʒss. | (15.0) |

M. S. Local use.

This should be painted over the corn for several successive days, at the end of which time the coating should be soaked off, and then the horny mass may be more or less completely detached.

Soft corns should be kept thoroughly dry and clean, and this condition is best secured by keeping the affected toes apart with absorbent cotton, after dusting the parts with borated talcum. This procedure usually brings about a cure, although at times it may be necessary to apply to the corn, very carefully, the nitrate of silver point, a drop of iodine, or the salicylic acid paint.

William A. Hardaway.

**Cleft Palate.**—By cleft of the hard and soft palate we mean a fissure of greater or lesser degree in the roof of the mouth, including, it may be, the alveolar ridge in front, and extending back to the extreme end of the uvula. These clefts are of two kinds, congenital and acquired, the former being by far the more frequent.

Pathology.—While during the past two decades our advanced laboratory opportunities in the study of embryology have brought us much valuable information, yet in the understanding of the congenital form of cleft there are many unsettled points and theories. Nature fails to accomplish the result intended, and the one theory so long entertained, that it was largely due to the lack of phosphates on the part of the mother, cannot now be satisfactorily maintained. "Careful experimentation, with both food and water, has failed to show any relation

between the mother's food and the occurrence of the defect." It is safe to assert that the same causes which produce rickets in children have also a like effect in producing cleft of the hard palate. Hereditary tendency has been mentioned by some authors, and this I have observed in the history of some of my own cases.

Mr. Lawson Tait, F.R.C.S., in his paper on "Cleft Palate" has very briefly, in somewhat different words, referred to this pathological condition, and is very strong in his belief that in certain localities it is quite endemic, and that, in his experience, heredity has been a great factor. He says he has known cleft to miss as many as three generations, and then appear in an hereditary form. The late Dr. Gurdon Buck reported a number of interesting cases of hereditary cleft occurring in his practice, upon which he operated with success. I lay much stress upon asking the parents questions bearing upon these points.

Brophy states: "First, let me say, heredity is, in my opinion, unquestionably a factor. Second, Force in embryonal life and the presence of supernumerary teeth."[1]

If we had some method of measuring the upper jaw, in cleft cases, and comparing the lower jaw in each instance with that of a normal child I am quite sure we would find the upper jaw wider in the former, from pressure of the mandible upward, during fetal life. Operators agree that in cases of congenital clefts the tissues are there, so far as proper amount is concerned, but not normally used.

Intermarrying is an element to be considered in the study of the pathology of these cases. In a practical clinical experience of over forty years I am greatly inclined to the belief that too frequent pregnancies present as a strong factor, also intrauterine injuries and various infections.

In a majority of cases in which the cleft is single, it is to be found on the left side, and the deviation of the two segments of the alveolar circle is fortunately, in these cases of single split, seldom great. My experience has been that, in double fissure through the alveolar ridge, the vomer often has its only support below in the intermaxillary projection, that is, the intermaxillary bone, or bones, appear as an appendage to the vomer, being held or assisted in position by fibrous, periosteal, and mucous tissues. This island of intermaxillary bones and tissues, which is so very noticeable in double harelip, especially when associated with double split or fissure of the alveolar circle, has been a source of deep study to histologists as well as to pathologists. The former have spoken of it as analogous to the premaxillary bones in some of the lower animals, and yet it has been very difficult to detect, in the youngest human fetal upper jaw, the difference between the intermaxillary portions and the lateral or true portions of this bone. However, we know that this so-called island does contain what may be termed the true intermaxillary bones and the temporary and permanent incisors, in cases of complete double cleft having only the middle ones perfect, the lateral incisors often being imperfect or entirely absent. This condition of the incisors I have observed in cases in which it became necessary to remove the island. Such instances of removal are fortunately rare.

Singular as it may seem, Fergusson states that this line of separation, just spoken of, cannot always be traced in the well-developed fetal skull; yet the suture remains quite distinct in the palatine portion of this bone until a late period of adult life.

The surgeon is obliged to take somewhat into consideration the structure of this island or the intermaxillary substance, in determining the line of treatment to adopt, and its unsightly appearance moves him to do an early operation for relief. This procedure is certainly a strong argument in favor of operating on both the cleft and lip within a few days after birth, if the conditions are favorable.

Cleft of the hard palate, as well as harelip directly through the mesial line of the intermaxillary bones and soft parts, is very rare. Tait says two specimens are known. I have seen one case of median harelip. Sir William Fergusson states that he has never seen a case. A great amount of literature on this point mentions but a few cases.

Maternal impressions are often suggested as a cause of this deformity. We can give but a very slight endorsement to this view of the question.

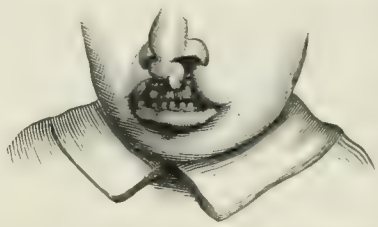

Fig. 1409.—Double Fissure of the Alveolus.

Congenital cleft of the hard and soft palates may be exceedingly simple, only the uvula being implicated, or it may extend forward to, or into, the alveolar ridge, and may double-fissure the alveolar circle (Fig. 1409).[2]

The fissure is often situated so that the vomer is to be seen in the middle of the split (Fig. 1410). At times the vomer is fastened to one or the other nasal side (Fig. 1411), generally to the left, and this location is always a source of embarrassment in operating. It is here that a combination of the Fergusson bone operation and the Warren operation—the former on the side free from the septum, and the latter on the opposite side, sliding the periosteal flaps—meets the emergency best. To break the vomer, as I did in some of my earlier cases, is not always a success, and we are more likely to get necrosis, especially of the septum.

It is well known that many infants born with this defect die within a short time after birth, when the cleft is of a marked character. Mr. Tait says that

Fig. 1410.—The Vomer is Seen in the Center of the Fissure.

Fig. 1411.—Showing the Attachment of the Vomer to One Side.

one-half of the children born with extensive clefts die within a few days after birth from starvation, and thinks we might be able to save many of these children if we could help them to suck by early giving them a roof to the mouth, and therefore advocates doing the operation for closing the hard palate as soon as the third week. My personal experience does not show so high a rate of mortality.

Markoe, in an interesting report, gives some valuable observation on the loss in weight in these infants.[3] When speaking of treatment I shall refer to this subject again.

Children born with cleft palate cannot nurse, nor can they, in many instances, use the large rubber

nipple of the nursing bottle with complete success. Mason, in his excellent work, mentions the large flat nipple, made so as to fill the roof of the mouth while nursing, as of great use.

When the children must be fed with a spoon, a great care devolves upon the mother or nurse. Among my cases I have the notes of two (a son and a daughter in one family) in which the mother, for nearly two years in each instance, was obliged to give nearly her entire time to the care of the two children, as regards feeding, before they could help themselves. In neither of these cases was an early operation done for closing the double harelip. (Fig. 1409 shows condition of the son.)

Later this case was successfully operated upon, in many ways illustrating the strong argument for waiting made by the older surgeons regarding closure of the palate cleft. Such views no longer prevail, for, by waiting, too frequently other tissues become seriously involved, and, in many instances, makes the operation more difficult.

Cases allowed to go on without interference beyond the second year are those that show the loss of voice and the nasal tone in so marked a degree. This often proves a source of great annoyance in after-life, keeping the possessor from society and from following many occupations. It is interesting, as we study the history of this subject, to note the views of different surgeons who have published their cases, as to the proper time for operation, especially in reference to the recovery of the voice.

I have now performed the operation so many times, in patients of from twenty months to nineteen years of age, that I am entitled to speak with some exactness and am convinced that our most successful cases are those upon which we operate early, before the child has made any great effort to speak. In fact, these children should not be encouraged to talk early. Most children make an earnest effort to talk at the end of the second year, and by that time the operation should have been performed. From my own observations of the results obtained by other surgeons who have closed the cleft as early as the second or third month of infant life, and from my study of the literature of the subject, as well as from my personal experience, I am not in favor of going as far as this in the direction of early operating. Young children do not bear the loss of blood well, and this must be respected. To me it has always seemed wise to inquire as to cases of hemophilia having occurred in the family.

Of this, however, I am certain, that in all these cases of cleft palate complicated with single or double harelip, the operation upon the soft external parts should be done as soon after birth as possible. With the large nipple and perfect lips to surround it, or simply by the use of the spoon, the child can be fed very well. The union of the soft parts does aid, I am convinced, in bringing together the bony vault of the mouth, a result which is very desirable. Then again, it does to a certain extent carry the child out of the domain of idle curiosity and observation, and thereby lessens the burden of the parents. (See remarks by Brophy bearing upon this subject, and quoted later on.) Some of these children will die before reaching the age of two years, not because of imperfect mastication, but because they are bound to bear their ratio of death with the rest of the infant family through gastrointestinal complications.

In a study of this subject, extending over many years, there is no one condition that illustrates so fully, and impresses one so much, as the advance made in infant surgery, and the sanction given by Lane, Brown, Brophy, Blair, Roberts, and many other able surgeons of to-day, in operating early to close the anterior cleft, bringing the island in line with the alveolar circle and repairing the harelip. My former objection regarding the loss of blood does not hold good, the technique to-day having become so clear that the fear of hemorrhage is not so great.

In double harelip, while the treatment of the island or intermaxillary bone has been dwelt upon very clearly by the various writers, I am sure that of all the different complications, it is in this that experience is of the greatest value, and that every case presents one or more peculiar features. To save the island when possible is, I think, good surgery. There can be no doubt that it prevents the child-like contraction or appearance which is so striking in some adult faces where it has been removed.

As to the manner of closing the harelip, there can be little difference of opinion. The law is inflexible that to produce a good result the vermilion border of the lip must be always on a line projecting a little, if possible. If not, an apparent notching occurs in the vermilion border.

Regarding the mode of dealing with the island, my preference is, if I cannot save the bone, to save the healthy skin covering it, be it ever so small, and to shape it in such a way that by angle, curve, or square I can fit it either into, between, or to one side of the upper lip, using the latter and tissue from the

Fig. 1412.—Showing the Notch of the Vermilion Border of the Lip Following Operation.

cheeks to form the lip. The small amount of skin covering the intermaxillary island can always be used to advantage to support the columnar portion of the nose and vomer, giving better form and shape to the anterior nares. Fig. 1412 shows a very difficult case and a depression of the vermilion border of the lip can be noticed. Fortunately as a young man he was able to wear a moustache, relieving all unsightly appearance. The result inside the mouth, and in the recovery of voice made this one of my most fortunate cases.

Regarding these cases in girls we must endeavor to do our very best work. Fig. 1413 presents one of great difficulty yet in which the vermilion border was well preserved, and in later years no trace of the operation could be observed. The small portion of skin thus saved with the island aids in its way to give an appearance of fulness to the face or upper lip. The saving of the island gives a better septum for the nose, as is reasonable to conclude. Removal of the island may cause other complications, such as contraction of the anterior nares.

In the case of a boy six months old, with double harelip, the intermaxillary bone was so prominent that I deemed best to remove it entirely. At the

first operation, when this was done, a lateral incision was made from the angle of the nose on each side outward into the cheek, and then the two flaps forming the upper lip were brought together; perfect union was thus secured. Later, and in his second year, two operations were required for closing the cleft in the hard and soft palate; but his voice did not improve as I had hoped. I did not see him for nearly three years, when he was brought to me, and on examination, I found that the upper lip had no union with the septum or vomer, and that through this opening the air escaped in so great a volume as partially to account for his defective speech. These cases are difficult to remedy.

In the case of a boy who was four years of age, and whose face was almost as much disfigured as was that in the case just narrated, I operated the same number

Fig. 1413.—Illustrating a Difficult Case in a Girl in which Saving the Island Aided in Preventing Deformity.

of times, but I did not remove the intermaxillary bone. The result obtained, as to appearance and voice, was nearly perfect.

I cannot refrain from speaking of my early experience in connection with these cases, as to the time of operating. So firmly then was it fixed in the minds of the family physician, surgeons, and parents that no operation should be done sooner than the tenth or twelfth year that in the beginning of my work it was a long time before I could gain consent to operate earlier.

Just here I wish to speak of the necessity of operating upon the soft parts in such a manner as not to leave any scar behind, and in doing this I am convinced that the kind of suture material employed has much to do with the result. Lawson Tait was among the first to make use of the silver wire, and from that time on many operators have suggested one kind of suture or another—horsehair, silk, linen, silkworm gut, harelip pins, catgut, kangaroo, copper enamelled wire, and some other devices. I am of the opinion that silver wire for the alveolar ridge, and silkworm gut and catgut for the soft parts give the best results, using as fine a needle as will answer to carry the suture.

In my article on *Harelip* I speak more fully on this subject, having little reason to regret the use of the ordinary silver harelip pins. I desire to state here that as my time became more precious it was necessary to have an assistant remove the pins, and leaving them for a day or two too long would, at times, result in a quick ulceration, this producing a scar, so that of late years I have used silk, silkworm, and catgut. Just when to remove the sutures from the lip is a point requiring careful watching and experience.

The subject of cleft of the hard and soft palate is one not so well settled in the minds of surgeons as to exclude further elucidation, and, while it is hardly safe for one to attempt to advance much that is new, I am convinced that a more careful examination of our cases, and of the reports of the same, one, two, or more years after an operation has been performed, is needed. It will ever remain a source of regret to the profession that such successful operators as Warren and Fergusson (the latter operating over three hundred times) did not leave a record as to how the operation ultimately affected the voice, the restoration of which is the principal object sought for in doing so difficult an operation. I say restoration of the voice, but it must also be remembered that the, now, early operation results in relieving the little ones of many gastrointestinal troubles.

I have seen a number of my cases, forty, thirty, twenty, ten, and five years after the operation, and have been greatly pleased regarding recovery of the voice. The younger the patient the better the result, and I am sure the nearer I have come to restoring the vault, by the bone operation, the less has been the loss of voice, and greater comfort in every way. On this point some very worthy contributions have been made by Dr. George V. I. Brown of Milwaukee, Wis.[4]

That it is a severe operation there can be no doubt, especially when the attempt is made to close a complete cleft. Furthermore, in my own practice, I have experienced repeated failures in a few cases. Nevertheless, in these very few cases, with one or two exceptions, I have finally conquered, and in none was the patient left any the worse for the future trial of an obturator. That persons do get on in life without any operation being done, and are then improved by the use of an obturator, is now a well-established fact.

I was well acquainted with the work of the late Dr. Kingsley and saw some of his successful cases fitted with an obturator having a flexible, movable soft palate, yet in the majority of instances they were disappointing. Recently I have seen a very successful result in the practice of Morton Van Loan, D. D. S., Dr. and Edgar A. Vanderveer, of Albany, which will be referred to when speaking of the use of obturators.

However, these cases are not always so benefited. A gentleman with whom I was acquainted, aged seventy, was operated upon when a child for harelip, by Guthrie, and then given to the dentists for relief when eighteen years of age. He was never in the least improved by the use of obturators, and life was ever to him a sorrow. It was with great difficulty that he could be understood. It is very evident that in the modern, up-to-date early operation for congenital cleft, little opportunity will be offered for the use of the obturator.

I have never yet been obliged to stop an operation because of a hemorrhage, but I have known it to occur at times in a severe manner. Blair,[5] in speaking of postoperative hemorrhage, minimizes the danger and covers control methods thoroughly.

I was once compelled to postpone an operation on account of the great and rapid secretion of mucus, it being so abundant that the bronchi filled to an alarming extent, and suffocation seemed imminent. When the second attempt was made I put the patient for twenty-four hours upon full doses of belladonna which had the desired effect of drying the throat and checking the free secretion of mucus.

Experience has taught us the importance of a more thorough and careful preparation of our patients, *i.e.* adenoids must be attended to first, the nasal passages put in as good condition as possible, tonsils,

in some instances, removed, and the pharynx well sterilized.

The subject of cleft palate is one that has occupied the minds of our best surgeons both in this country and in the old world, and each can claim a good degree of success. It is not necessary at this point to enter into the details of the history of the operation. It is enough to know that Langenbeck, Fergusson, Warren, Billroth, Lawson Tait, Francis Mason, T. Smith, Goodwillie, Prince, and many others of our own time, have given the matter careful consideration. It is an operation in which experience is of service as to dexterity, as to time consumed in doing it, as to teaching the mother or nurse how to improve the speech afterward, and also, I believe, as to the choice of the proper time for operating. I think that, if we could get honest statistics, we should find the best time for operating to be immediately after the first dentition, or when the child is about two years old, and that previous to this no attempt should be made to encourage the child to talk. Then there is not so much danger of acquiring that nasal twang which is so difficult for an older person to overcome. The rule stated above should also apply to cases of incomplete cleft, in which there is no harelip.

In the light of experience gained during the past decade these remarks will bear some considerable change. To American and English surgeons, and American dentists, we are greatly indebted for advances made in doing the operation much earlier. No surgeon now advises waiting later than the last half of the second year. The concensus of opinion is that in a well-developed child, with single or double cleft, single or double harelip, the operation can be

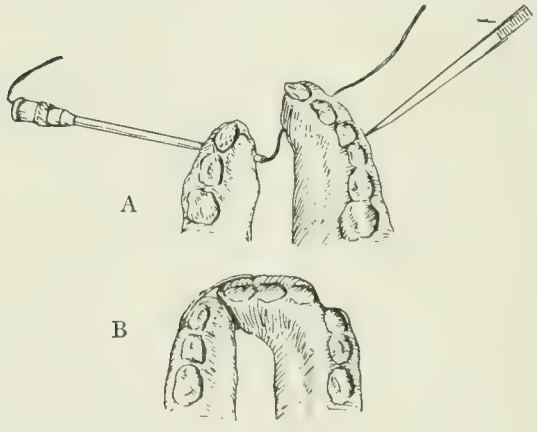


Fig. 1414.—Correction of Alveolar Cleft. A, A small chisel is inserted between the roots of the cuspid and incisor, and the bone is fractured up into the nasal fossa. Before doing this, a wire is inserted through the alveolar process on each side of the cleft by means of a trocar and cannula. B shows the fractured part of the alveolar process bent over to fill the gap, and the wire twisted to hold the bone in place.

done with safety, in quite a large percentage of cases, soon after birth. Most of these cases can, when the operation has been a success, nurse or take the nipple within two hours after, thus gaining in weight, and not losing as so many infants do after birth, when no surgical treatment is admitted of.

As to the treatment of the lip and soft parts an effort should be made to use that kind of a suture that will not cause infection, or itself become infected, if possible doing away with the employment of any form of plaster. The use of the silver wire, in bringing in line the intermaxillary island, and the anterior portion of the alveolar circle, is of great importance, (Fig. 1414) the soft palate being left for complete operation during the second year. A delicate child must receive careful consideration. Even in the more desperate cases some operative intervention will be tolerated much earlier than at one time was believed possible.

The time of operating, and the chances, in the severe cases, as well as the method of operating, must be left entirely to the past success and skill of the surgeon or dentist operating. It is here that good judgment and familiarity with such cases is of value.

*Staphylorrhaphy* is an operation suited especially for closing a cleft of the soft palate, also such as are associated with but slight fissures of the hard palate.

*Osteoplasty* is essentially the bone or Fergusson operation. I was greatly impressed in seeing Sir William Fergusson do this operation and I am sure there is no procedure that comes so near restoring the parts to their normal condition. It is true the cases are somewhat limited, in which it can be employed; such as have a fair development of arch along the alveolar ridge being the most suitable, but I have long observed that the results, regarding restoration of the voice, are far better than in some other methods employed.

Next to this operation, in frequency, I have done the Langenbeck and Warren operations, making as much of a periosteal flap as possible, and I am certain I have seen a bony arch develop.

The Fergusson, or bone operation has been modified in several ways, the most decided of all being the Brown and Brophy operation. Dr. G. V. I. Brown recently performed some very interesting experiments upon dogs, regarding palate operations and has also referred to the question of securing better results, regarding the voice, and which, I am sure, will lead surgeons to consider more thoroughly as to the kind of operation that, by later observation, determines the least embarrassment of speech.

I have combined the two in closing a complete cleft of both hard and soft palates, and have had no reason to regret it, although it is a severe operation; however, I believe that in a careful study of the experience of all operators we reach the conclusion that better results follow, in the treatment of these cases, by the two operation methods, and with less mortality.

*Steps of the Operation.*—The child's bowels having been moved the day before, no solid food should be given on the morning of the operation. I was once greatly embarrassed in a case in which the nurse had given the child a plateful of oatmeal gruel, which it continued to vomit during the entire operation.

For further valuable suggestions on preparation of the patient I would earnestly recommend careful study of very valuable papers by M. L. Rhein[6] and Brophy.[1]

My greatest objection to the use of lead plates, perforated shot, the abominable quill suture, or its modifications, is the difficulty of keeping the mouth clean. I believe they are factors causing sloughing of the tissues in these cases, and then the less you have to do with the little ones after operation the better.

In these operations I do not hesitate to make use of chloroform, and especially in children under ten years of age; however, of late years I find I have been giving ether quite frequently, and that many of our surgeons of to-day prefer this anesthetic. Before the anesthetic is given everything should be in readiness and each assistant should be instructed as to his work; then, as the little one comes under the influence of the anesthetic, the operation should begin with promptness. It is true many of these children are of feeble make-up, but the cases are few in which one need feel at all anxious in giving the anesthetic from a small napkin, plenty of air being allowed. When the anesthetic takes effect, the Whitehead gag, which I consider the best (as shown in Figs. 1415 and 1416) should be introduced. In using this instrument one

must be patient in the workings of the tongue depressor. Dr. Brown has a modification of this gag which seems to be of value. Of all the other contrivances to keep the mouth open, and of which there are many, I consider the Lane gag (Fig. 1417) the most

Fig. 1415.—The Whitehead Gag.

useful. It is wise to have at hand a Luer's cheek retractor, Fig. 1418, and Roe's mouth gag and cheek retractor, Fig. 1419.

Regarding the care of the tongue during the operation the ordinary, angular tongue depressor has

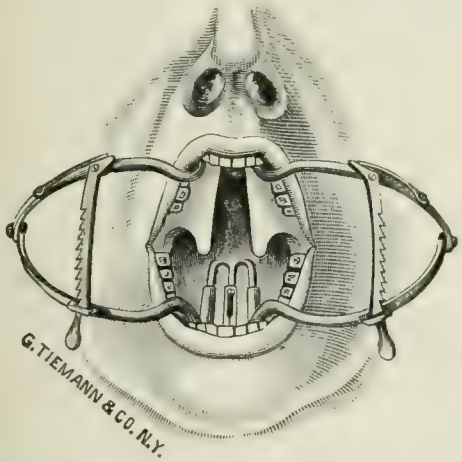


Fig. 1416.—The Whitehead Gag in Position.

given me the best assistance. It is remarkable how soon we learn to avoid the tongue, and the simple method of passing through the apex a double silk ligature helps, by the aid of an assistant, to control it exceedingly well, and without giving embarrassment in the administration of the anesthetic.

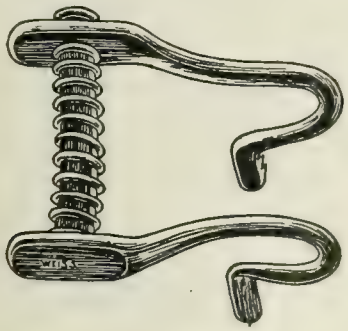

Fig. 1417.—The Lane Gag. (Blair.)

The operator should have ready a good supply of bits of sterilized gauze, not too large, with at least a dozen good sponge holders, long enough to reach well back into the pharynx. It is necessary, also, to have near at hand a bowl of cracked ice, in which to dip the bits of gauze intended for use in controlling severe hemorrhage. All instruments should be of metal and carefully sterilized.

The surgeon requires as his assistants, one to give and watch faithfully the anesthetic, another to sponge, a third to hand the instruments, and assist generally, and two good nurses to look after the mops of gauze.

The operation should be performed in front of a good light, and the patient's head should rest on a firm pillow. Every lying-in hospital should have a good, well-lighted room in which to do this operation.

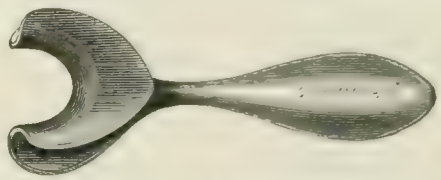

Fig. 1418.—Luer's Cheek Retractor.

Keep the mother and child together, if conditions will permit.

Some operators speak very favorably of letting the child's head hang over the table, the blood being sponged out as it collects in the posterior part of the pharynx. Of late I have become greatly impressed with this method, which is so favorably endorsed by Dr. Campbell, of Brooklyn,[7] in his excellent paper on The Method of doing the Lane Operation, with report of cases.

The essential steps of the operation are as follows:

1. Standing on the right side of the patient with forceps or tenaculum (Figs. 1420 and 1421), the op-

Fig. 1419.—Roe's Mouth Gag and Cheek Retractor.

erator grasps the lower end of the uvula, on the left side, and with long, sharp-pointed narrow knife (Fig. 1422), freshens well the edges of the fissure, not hesitating to take away plenty of tissue, and frequently doing it without removing the instruments; in which, of course, much will depend upon the bleeding, and how well the child is under the influence of the anesthetic.

2. With an awl-shaped instrument (Fig. 1423), holes are bored through the bone near the edge of the cleft, for passing the sutures; however of late years I have not found this step in the operation necessary.

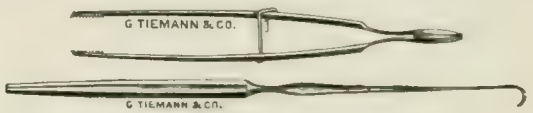


Fig. 1420.—Forceps and Tenaculum.

3. Similar holes, two to form on each side, are drilled through the bone along the alveolar ridge, sufficiently in front and not so far back as to interfere with the important blood-vessels, and then, by means of the chisel (Fig. 1424), the parallel portion of bone is pressed, or rather forced, toward the median line for the purpose of closing the cleft in the hard palate with bone and periosteal substance.

4. The blue and red silk forming the sutures are then passed alternately in the following manner, as shown in part in the accompanying illustrations: A blue silk is first passed through the nasal periosteal

edge, in the left side of the cleft, by means of the long, curved needle (Fig. 1425), and the free end is drawn out by means of the long forceps; next, a red silk, doubled so as to form a loop, is passed in the same

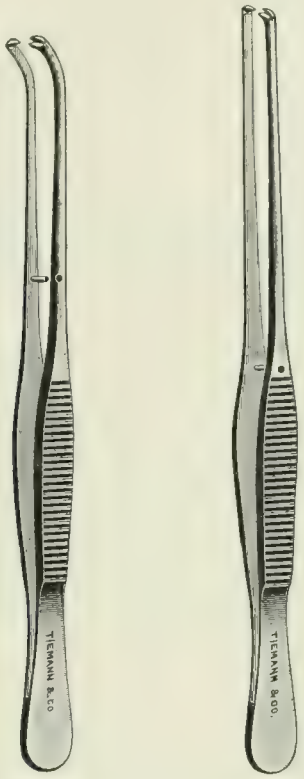


Fig. 1421.—Mouse-tooth Forceps.

manner through the periosteal flap, right side of the cleft, the loop being drawn through, and in this is engaged the free end of the blue suture in order to draw it through on the right side, thus completing its passage, as seen in Fig. 1427 A, B, C, and D. I have,

Fig. 1422.—Fine-bladed Scalpels.

in some cases, passed the suture around the bone split from the alveolar ridge with success. In this way as many sutures as are needed are passed, the red and blue alternating. It is not necessary to use

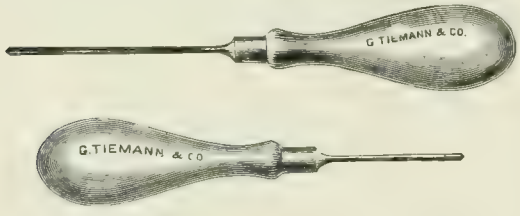


Fig. 1423.—Awl-shaped Instruments for Boring Holes for Sutures.

the colored silk, but the beginner will find it a great aid.

In my first operations I endeavored to use a moderately small, curved needle, like the Brophy and Lane of to-day, but later adopted the Peaslee, and the right- and left-handed needle with good metal handle.

The method and kind of needle employed is of

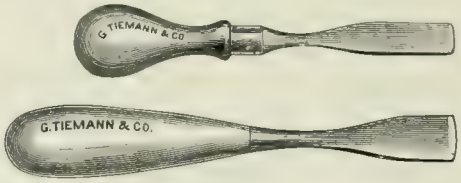


Fig. 1424.—Chisels for Forcing the Bone toward the Median Line.

great importance. I have a great collection of instruments for passing the suture in cleft palate, but desire to state that I have had more comfort in the

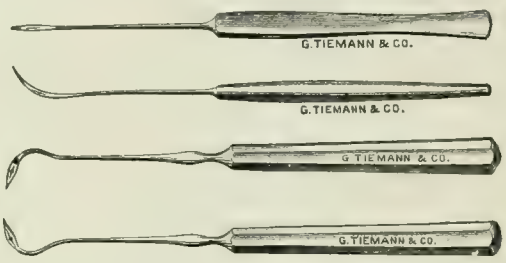


Fig. 1425.—Curved Suture Needles.

use of the Peaslee needle, having several different curves, than any other.

The material for suture must be left to the judgment of the operator, would say that in doing the sliding operation, when loosening the tissues from the alveolar circle, and passing through and relieving the attachment at the nasal edge, I have observed the flaps came in good approximation, without the necessity of having freshened the edges.

5. Tying the sutures is next done by means of the slip-knot. A half knot is thrown around the free end of the suture (Fig. 1427 D), and then by the use of the fingers or instrument (Fig. 1428), the knot is pressed tightly down against the edges of the cleft—which are thus brought together—and tied twice, as shown in (Fig. 1429), the suture being drawn to one side of the fissure and cut short with curved scissors. This closes the entire cleft completely in one operation.

Fig. 1426.—Whitehead's Spiral Needle.

6. This is a very important step in many operations. It consists in dividing the tissues at the point where the greatest tension exists. In examining my patients I was early greatly impressed with the observation that when they attempted to swallow and when they breathed with the mouth open, the two sides of the fissured soft palate very nearly, if not quite, came into apposition, except just opposite the hamular process and at the junction of the hard and soft palates; and, at the same time, there was thrown up on the posterior wall of the pharynx a transverse ridge formed by the superior constrictor, the latter aiding to prevent the passage of air or food up into the posterior nares. This observation led me to make the lateral incisions in the soft palate only at the point of greatest tension, and that being the tendon of the tensor palati, to

buttonhole it, as we may say, with a short, blunt knife (Fig. 1430), after Fergusson. A straight knife cutting from before back will do as well.

There are arguments for and against this lateral incision to relieve tension in the soft palate, and particularly of the tensor palati. Of late the method

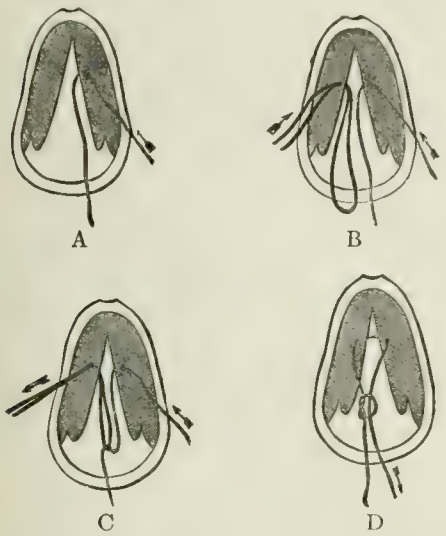


Fig. 1427.—Successive Steps in the Passage of the Sutures.

of doing the operation, as suggested by Brophy, would lead one to believe he is correct, and that the making of a lateral incision is not always so absolutely necessary. The relief afforded by this procedure, however, is at once marked, and while at times the

Fig. 1428.—Knot-tier.

hemorrhage is decided, yet it can readily be controlled by pressure of the vessel.

This is essentially the same procedure as that of dividing what Mr. Lawson Tait so ably described in his paper as the circumflex fascia belonging to the tendinous insertion of the tensor palati muscle, a failure to divide which so often causes non-union of the hard and soft palates. Dr. David Prince, in a paper on "Palatoplasty," very clearly and ably discusses this subject.

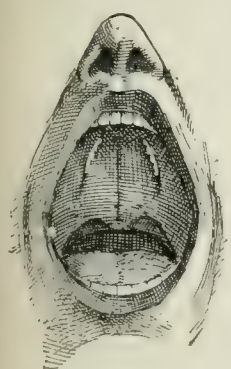

Fig. 1429.—The Edges of the Cleft Brought Together with Sutures.

Fig. 1431 shows the appearance of the mouth when the combined operations have been performed; the lateral alveolar incision having been well packed with strips of iodoform gauze. This step I consider essential, as it prevents the too quick union of this free incision, which is sometimes apt to occur. It is well to repack the incision on the third, fourth, fifth, or sixth day, the judgment of the operator determining the exact time.

When simple staphylorrhaphy is to be performed, the steps are much the same; the use of the awl and chisel in bringing the edges of the bone together should, however, be omitted and where the hard palate is implicated the Warren-Langenbeck periosteal operation of sliding the covering of the bone as needed, should be performed. This is done by first making an incision through the mucous membrane and periosteum with a blunt-edged knife; then, with periosteal elevators (Fig. 1432), with which I have become so familiar, I can reach any portion of the field desired, although I would call attention to the ones suggested by Brophy and others (Fig. 1433), as possessing great merit.

The tissues should be lifted from the bone and toward the median line, the point of the instrument being carried posteriorly near to the posterior palatine arteries. This procedure, as Mr. Tait has observed,

Fig. 1430.—Fergusson's Knives for Relieving Tension.

raises the vessels from their bed without injuring them. The point of the raspatory must not be introduced into the canal containing these vessels. Mr. Tait believed that if the muco-periosteum of the hard palate be elevated with a raspatory from the semilune of the palate bone, the tendinous attachment of the tensor palati will be raised with it, and the muscle will thus be paralyzed, thereby doing away with the necessity of any such division of muscles as practised by Pollock or Fergusson, and diminishing the risk

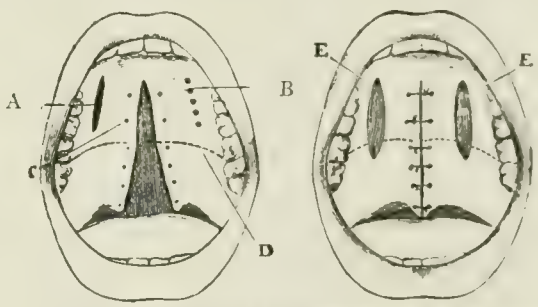


Fig. 1431.—*A*, Preliminary punctures with awl to give line for chisel; *B*, incision through bone completed by chisel; *C*, holes bored through hard and soft palate for sutures; *D*, junction of hard and soft palate; *E*, lateral openings subsequently filled up by granulations. (After Thomas Bryant.)

of there being a pinhole orifice at the junction of the hard and soft palates. After this, if tension of the soft palate be present, divide as before spoken of.

In any operation, early or late, some blood will get into the stomach. Brophy has suggested syphoning out the stomach immediately after the operation, and I believe a mild lavage afterward is of service in relieving gastrointestinal irritation. In further care of these patients I very much prefer to have a nurse who has had charge of previous like cases.

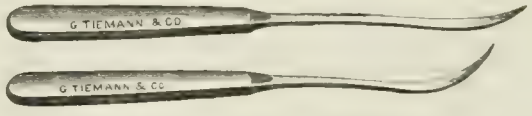


Fig. 1432.—Periosteal Elevators.

Anodynes are generally called for, but must be used with great caution. Within a few hours have the child try taking the breast or nipple of the bottle. If not successful artificial food, or milk—but selected with care—must be given, not urged. The hunger of the child will develop the two- or three-hour method of feeding, as in normal cases. The child must be kept warm, and, if permissible, being along side of the mother will comfort it. Mild mouth washes are to be employed, after nursing, but with

great care. Movements of the bowels should be carefully observed, one should note that digestion is going on in a proper manner.

The length of time during which the sutures should be left is of importance. Tait left them fourteen days and used silver wire. Prince also used silver wire. Mason used silk, and in many instances let them ulcerate out. Other surgeons have suggested and used horsehair. I always use silk and remove

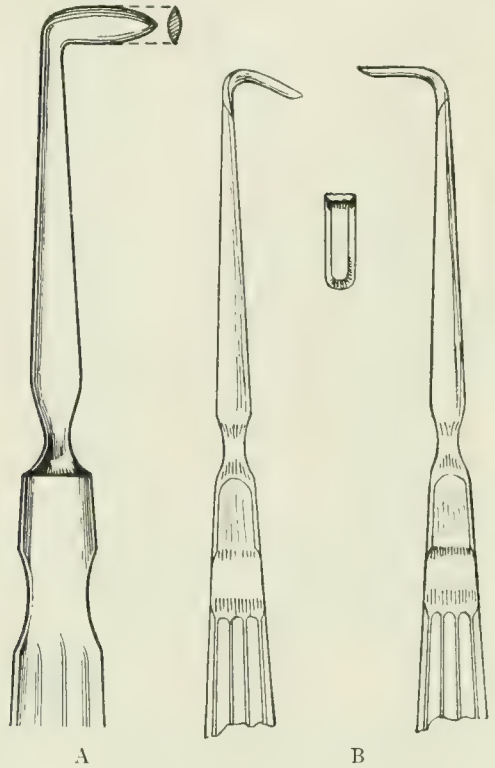


Fig. 1433.—*A*, Bartlett Elevator. *B*, Brophy Palate Elevators. (Blair.)

some stitches as early as the sixth day, and the remainder by the tenth. In removing the sutures it is well to put the patient under the influence of chloroform. Use long forceps and sharp-pointed scissors (Fig. 1431).

I am of the impression that where sloughing occurs, in the use of metal plates and shot, it is largely the result of leaving them in too long. While on this subject I wish to say that I witnessed their introduc-

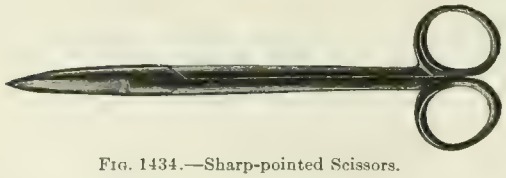

Fig. 1434.—Sharp-pointed Scissors.

tion, in doing this operation, with much interest, and in the final analysis fully agree with Blair. They are seldom, if ever, needed.

A word as to the incision of the posterior pillar of the fauces, as mentioned by Mr. Thos. Bryant. I have observed that there is a great difference in individuals, as regards the breadth of the space between the anterior and posterior pillars of the fauces, and where the soft parts are found to be very tense the posterior pillar may be divided; but we have been warned by Mr. Tait that atrophy of the soft palate is likely to follow this operation, an outcome which is to be regretted. I have noticed this condition in one of my own cases.

In some instances it will be noticed that when the operation is completed the child will have trouble in breathing, which can be relieved by the use of the breathing tube, referred to by Blair (Fig. 1435).

Many cases require two and three operations, but we should not be discouraged. Contrast a good result with the frequent necessity of changing the obturator, and the care required in looking after it.

In doing this work the surgeon should be inspired with the belief that no case is so severe but that it can be relieved, especially if he is called to see the child soon after birth.

When the operation is completed there must be no tension of the tissues. While surgeons may not be a unit on the method of operating, yet in this respect all agree. It is here that the Lane operation has apparently a great advantage, for the operation being done so early, before dentition, we can secure a greater amount

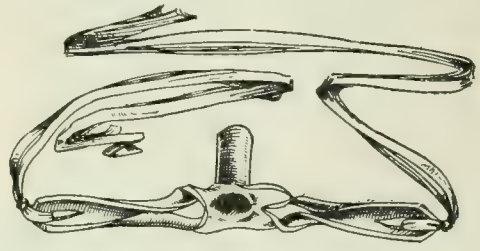

Fig. 1435.—Breathing Tube Made of Soft One-fourth-inch Gum Tubing, to be Used in Case of Difficult Respiration After Operation for Harelip. The tube is inserted in the mouth, above the tongue, and the tapes are tied behind the head. (Blair.)

of flap material. "Mr. Lane performs this operation on infants a few days or weeks old. The vitality of the flap is said to be sufficient to prevent sloughing occurring to any extent, and if non-union occurs at any part, a secondary operation to close the hole is performed later. When there is a harelip, as well as a cleft palate, the operation for the repair of the lip is performed either at the same time as or after that on the palate. It is very difficult to obtain reliable information as to the ultimate results of this operation. The immediate mortality is admittedly high. That the defect can often be closed at the time of the operation by this proceeding is quite certain, but what is required is to know the subsequent fate of the flap and how the patient speaks. We have seen several cases in which the flap has undoubtedly atrophied and large holes have been left; in others it has been evident that the whole flap has sloughed and the palate left in such a condition that further operation was quite impossible. The soft palate is frequently very deformed owing to the contraction of the scar tissue; moreover it is often stiff and rigid instead of being freely mobile. Most important of all, however, is the question of speech in a person who has been operated on by this method. At the demonstration of cases before the Surgical Section of the Royal Society of Medicine (May, 1911), very few patients were shown who had been operated on by this method and who were old enough to talk or to answer questions intelligibly; and therefore we are still left without reliable information on this important point."[3] Sutures ought not to cut out in the Lane operation.

In case of a rigid velum, occurring after operation, much good results from good, intelligent massaging, by use of the rubber-covered finger. I have not seen any unpleasant results from a short uvula, even if at an angle, or in its entire loss.

Fig. 1436 shows the little pinhole opening (in some cases larger), which may often be closed by the persistent use of some caustic, such as nitrate of silver or nitric acid.

In reviewing the important subject of uranoplasty one is impressed with the keen attention it has received, and is receiving, from the ablest surgeons and dentists, especially during the past decade or two, and, like many surgical questions in that time, is being reached in a manner much to the credit of the operator and comfort of the patient.

I would say then we should thoroughly consider the Fergusson bone operation, the Langenbeck-Warren sliding periosteal flaps; the Lane operation, of turning one flap under the other, and, as is so well shown by Campbell—previously quoted—and thoroughly worked out by Blair, the Brophy operation, presented by the same author. J. Baldwin,[9] gives an interesting report on this method of operating that is worthy of careful study.

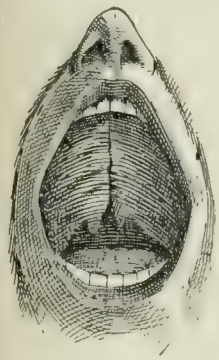

Fig. 1436.—Pinhole Openings Sometimes Remaining After the First Operation.

Strong opposition to this manner of operating has recently been presented by Brown, who objects to the turning over of the flaps. He states that it does interfere with the formation of bone and that in later years it has been demonstrated this method precludes the development of a bony vault of the mouth.

In doing this work the surgeon must not overlook the assistance that can be secured in working with some up-to-date dentist. The very difficult cases are much benefited by the treatment suggested by Brown, Blair, and Schroeder; also, bearing upon this subject, I would call attention to an excellent paper, with discussion, on "The Hospital's need of a Dental Staff," by Andrew . Flanagan,[10] D.D.S., Springfield, Mass.

Our very best recent contributions have come from American dentists. The use of the Haines' truss, by compression, in treatment of harelip and cleft palate, has never appealed to me, early trial affording little encouragement, and this, apparently, is the opinion of the latest writers on the subject.

When so much is being done, and many excellent suggestions offered, surgical intervention is destined to result in a more harmonious and perfect operation. It is rather remarkable that in past years the work in this department of surgery contained so many valuable suggestions, and only awaited a better understanding of embryology and the aid of modern surgery to bring success.

In harelip many operators have advised doing the operation early but in cleft palate it must be admitted such a procedure is of more recent date, although, as previously mentioned, Tait favored a very early operation.

The operator who is about to do this kind of surgery should carefully study every step bearing upon the urgency of confining his work to the two stages, not attempting too much in one operation—a mistake made by us older surgeons, and, in some instances, resulting in destructive sloughing.

A large number of cleft cases are clear and distinct, and the principles embodied in the proper operation are now so well defined that when once the surgeon has his technique well in hand uniform success is pretty certain to follow.

Blair, in his excellent book[5] has given a very remarkable classification of clinical types of congenital cases, and in so forceful a manner that this chapter is worthy our entire confidence. Like all surgical lesions there are cases that require special methods in treatment, and some of these come under the suggestions now made of taking flaps from entirely new sources—extrapalatal—such as from cheeks, face, and neck. To the clear and concise papers appearing in our medical journals and text-books the student and operator of to-day are earnestly recommended.

*Training the voice* after the operation is of great importance, as regards the final result. Great patience is required, and we must not expect improvement to follow immediately. A year, or even a longer time, may be required. With children I have had greater trouble in teaching the pronunciation of ch, as in church, chicken, etc., than that of any other sound.

Dr. Henry J. Bigelow,[11] of Boston, in a very able manner, presented the following views, regarding teaching children to talk after the operation had been performed. He says, "some years since I devised a short series of exercises for a patient I had operated upon. It begins with the only consonant which a patient can usually best articulate, namely, 't' in 'tar,' and gradually leads to the rest, constantly referring to the acquired 't' as a point of departure. The great difficulty in pronouncing with a cleft palate is in distinguishing the nasals from the mutes; thus, p and b from m; pab or bab from man; t and d from n; tat for man; k and g (hard) from ng; 'tar' is well pronounced by most beginners with an obturator. When the beginner can pronounce 'stark' and 'car' he has the key to most of what here follows. The above words should be practised carefully; not 'start' and 'tar,' but 'stark' and 'car,' and should be spoken loudly, or, as the elocutionists say, "exploded."

| | | | | | |
|---|---|---|---|---|---|
| 1. tar | artar | kar | arkgar | kar | |
| 2. kar | arkar | arkgar | kgar | gar | |
| 3. kar | arkar | arkdar | kdar | dar | |
| 4. kar | arkar | arkpar | kpar | par | |
| 5. kar | arkar | arkbar | kbar | bar | |
| 6. kar | arkar | arklar | klar | lar | |
| 7. kar | arkar | arksar | ksar | sar | |

Practise all the above with the following vowels:

8. o as in coke.

Thus, instead of kar, akar, etc., ko–oko–oklo–klo–lo.

9. a (long) as in cake.
10. i as in kite.
11. e as in keep.
12. u as in suit.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13. kar | arkar | arngar | arkar | arngar | kar | ngar | |
| 14. tar | artar | arnar | artar | arnar | tar | nar | |
| 15. par | arpar | armar | arpar | armar | par | mar | |
| | | | | | bar | mar | |
| Practise reading loudly from a book: | | | | | dar | mar | |
| | | | | | sar | rar | |

In the case of children beyond twelve years of age, and particularly with adults, I would perform the operation for closing cleft palate, if for nothing more than to afford comfort in eating.

The acquired form of cleft is the result of a variety of diseases and accidents. Of the former the most frequent is constitutional syphilis, in the adult. In children it is usually the result of a fall, while running with something in the mouth, as a bean-blower, pencil, or pen, the force being such as to drive the article through some part of the roof of the mouth. These forms of fissure are situated strictly behind the alveolar ridge, and, as a usual thing, are not large.

Regarding the treatment of the acquired form of cleft, I should, in all cases of traumatic origin, operate by forming the periosteal flaps. In cases in which constitutional syphilis is present the Wassermann test should be employed with much earnestness, and if the diagnosis is confirmed no operation should be undertaken until all traces of the disease have disappeared. I am only relating the experience of myself, and other operators, in stating that to operate on syphilitic tissues brings a large percentage of failures.

It is to be observed that syphilitic lesions of this kind have decreased very decidedly the past two decades.

Occasionally the acquired cleft is the result of tuberculous ulceration and then the operator needs to be exceedingly careful that no active bacilli are present in the system of the patient.

Figs. 1437 and 1438 (from Morton Van Loan, D. D. S., Albany) illustrate the most successful and useful form of obturator and soft movable velum I have

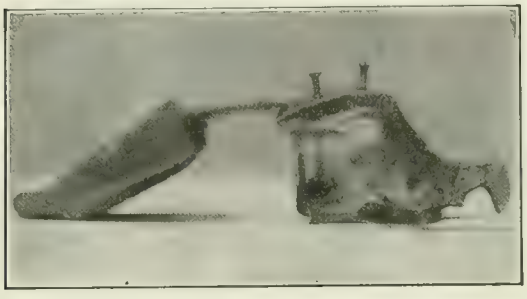

Fig. 1437.—Van Loan's Obturator and Movable Velum.

ever seen, by which he treated an adult case of congenital cleft palate, previously unsuccessfully operated upon by several surgeons. Like all mechanical adjuvants this apparatus requires great care.

*Congenital Cleft.*—All along, in the attempts at treatment of cleft palate, an effort has been made, by various surgeons, to introduce an artificial palate, soon after the birth of the child, to enable it to take nourishment; however, none of these mechanical contrivances seems to have met with any great success.

Fig. 1438.—The Parts, Shown in Fig. 1437, Joined.

An unusually interesting case of acquired cleft, and treatment, is reported by Haslett.[12]

Few operations return a greater amount of gratitude, on the part of the parents and patient, than successful work in uranoplasty.

The amount of comfort afforded in eating, and care of the mouth, cannot be expressed. Patients who have endeavored to use an obturator, and then had a successful operation, are most emphatic in their expressions of relief. ALBERT VANDER VEER.


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**Cleveland.**—The first city of size and importance in Ohio, situated on the south shore of Lake Erie at the mouth of the Cuyahoga River. It is a large and handsome city of 560,663 inhabitants, and from the abundance of its shade trees is called the "Forest City." The climate is indicated by the accompanying table:

CLIMATE OF CLEVELAND, OHIO—LATITUDE, 41° 30′; LONGITUDE, 81° 42′. PERIOD OF OBSERVATIONS, THIRTEEN YEARS.

| Data. | January. | July. | Year. |
|---|---|---|---|
| Temperature (Fahr.)— | | | |
| Average or normal | 26.8° | 71.9° | 48.9° |
| Average daily range | 13.7 | 14.9 | |
| Mean of warmest | 32.8 | 79 | |
| Mean of coldest | 19.1 | 64.1 | |
| Highest or maximum | 70 | 96 | |
| Lowest or minimum | –17 | 49.6 | |
| Humidity— | | | |
| Average relative | 77.9% | 70.1% | 71.2% |
| Precipitation— | | | |
| Average in inches | 2.50 | 4.21 | 38.40 |
| Wind— | | | |
| Prevailing direction | S.W. | N. | S.E. |
| Average hourly velocity in miles | 10.7 | 7.3 | 9.3 |
| Weather— | | | |
| Average number clear days | 2.8 | 9.6 | 83 |
| Average number fair days | 8.4 | 15.7 | 141.8 |
| Average number fair and clear days | 11.2 | 25.3 | 224.8 |

EDWARD O. OTIS.

**Clifton Springs.**—Ontario County, New York.

POST-OFFICE.—Clifton Springs. Hotel and sanitarium.

ACCESS.—Via Auburn branch of the New York Central and by the Lehigh Valley railroads.

This resort is located in one of the most healthful parts of the State, midway between the villages of Geneva and Canandaigua. The location is about 617 feet above the sea level, and the surrounding country is somewhat hilly. An average summer temperature of about 75° to 85° F. is the rule. The springs are very numerous.

The following analysis was made in 1902 by Richard Sydney Curtiss, Professor of Analytical and Research Chemistry, Union University, Schenectady, New York:

| PARTS (BY WEIGHT) IN 10,000 PARTS OF WATER. | |
|---|---|
| Potassium chloride | .060 |
| Sodium chloride | .026 |
| Sodium sulphate | .428 |
| Acid sodium phosphate | Trace. |
| Magnesium sulphate | 3.241 |
| Calcium sulphate | 10.339 |
| Calcium carbonate | 2.876 |
| Alumina | .015 |
| Iron | Trace. |
| Silica | .076 |
| Carbon dioxide | .700 |
| Hydrogen sulphide | .110 |

(Equivalent to 1.665 cu. in. gas in one U. S. gallon.)
Reaction, slightly alkaline.
Specific gravity at 60° F., 1.002.

This water is quite similar to that of the Greenbrier White Sulphur Springs of West Virginia. It is used to supply the Clifton Springs Sanatorium, the important feature of this resort. All varieties of baths are here to be found, as well as all the modern appliances and methods of using electricity. The use of massage, the Swedish movement, and the various forms of gymnastics also receive due attention. Especial attention is paid to the treatment of heart disease by Nauheim baths and Schott movements.

The hot-air treatment for rheumatic and gouty affections by which absolutely dry air may be applied at any temperature up to 400° F., followed by massage and manipulation of stiffened joints, affords great relief and often brings about permanent cure.

Excellent results are obtained by the use of mechanical vibratory stimulation by which relaxation is produced as well as improvement of affected nerve centers along the spine and in other parts of the body.

The Sanatorium, including a large Annex, is a fine modern building located in a wonderful park of old forest trees, sixty-two acres in extent, forming beautiful groves. Here are spacious pavilions, attractive walks, miniature lakes, and flowers. The buildings are provided with all modern contrivances for the comfort and health of the guests—steam heat, electric light and gas, elevators, and electric bell service. A fine veranda, a large solarium, and a roof garden are among the attractions.

Bowling alleys and a gymnasium are on the ground floor. Besides, there are croquet and quoit grounds, golf and court golf, tennis court, and many pleasant walks to near-by points of interest. The roads about Clifton Springs are exceptionally good for driving or wheeling.

Rheumatism, gout, and diabêtes are studied and treated with special care. There is fine equipment for the treatment of chronic diseases such as anemia, Bright's disease, and paralysis, while convalescents from acute diseases and surgical operations find here a most comfortable retreat. The treatment of lumbago, sciatica, constipation, insomnia, and various nervous disorders receives special attention.

Clifton Springs seems especially adapted to the treatment of business and professional men and women who are "run down" from overwork and strain. The house is kept open for guests all the year, but the greater number visit the place during the summer months.

EMMA E. WALKER.

**Climacterics.**—The body is constantly changing, though not at a uniform rate. At times there is a halting, and again the changes are precipitated, especially at certain periods of life. During the reign of empiricism, observation led to the placing of special stress upon the periods of uneven number. The Greeks recognized especially five periods, which they denominated climacterics, from climax, which signifies a gradation. The first climacteric of the Greek physiologists occurred at the seventh year, and the subsequent periods were determined by multiplying by the figures three, seven and nine; viz., twenty-first, forty-ninth, sixty-third, and (nine by nine) eighty-first years. Possibly we could arrange a scale that would be more satisfactory to us, but the general principle is well worthy of our attention. The two latter periods, sixty-three and eighty-one years, are denominated the grand climacterics, under the impression that after them nothing especially is to be accomplished save a preparation for the grave.

The climacterics are of especial interest to physicians, since at these times there may occur sudden changes in health, either favorable or unfavorable. Possibly we are too much inclined, at the present day, to disregard the diseases or changes not founded upon known pathological alterations. The old masters in our profession were more adept than we in the art of observation. However, we to-day recognize disturbances at certain periods of life, notably at the period of dentition, the period of puberty, and the menopause. These periods show other changes and diseases than the mere eruption of teeth and the appearance and disappearance of menstruation. Likewise, the decline of life shows changes that are arrested or precipitated at certain stages, rather than a uniform decline, though the changes in the later years are not so readily studied as in the earlier years of life. For late in life there are many disturbing elements, when passions and care, grief and anxiety may obscure the natural changes.

The changes at about sixty-three years of age have been frequently remarked. Probably any physician of much practice has observed patients at this age decline in health without apparent cause, possibly to such an extent as to cause them to give up business or professional activity, in some instances presenting the appearance of impending dissolution, with later a return to robust health. At the time of this period, aptly termed the grand climacteric, there is often marked despondency without apparent cause, sometimes a gloomy foreboding of poverty or extravagant grief. Later these conditions of the mind disappear apparently spontaneously. The literature teems with reports of cases of white hair becoming dark (though more often the opposite change takes place), of the appearance of a third set of teeth, and of marked improvement in sight and hearing.

During the depressive stage of the grand climacteric, the general resistance of the individual is markedly lowered. At this time it is wise to establish such rules as will tend to increase the nutrition, diminish waste, and prevent mental shocks. This stage has been aptly termed the "sixty-three" disease. In many respects it bears a marked resemblance to the normal marasmus or atrophy of old age, from which it differs essentially in the tendency to complete rally and recovery.

The changes of the grand climacteric at sixty-three are usually more pronounced in men than in women, the latter being more affected at the earlier climacteric, about the time of the menopause.

Discussing the symptomatology of the grand climacteric, Sir Henry Halford observed that the patient perceives that he is tired sooner than usual, and that he is thinner than he was; but yet he has nothing material to complain of. In the process of time his appetite becomes considerably impaired; his nights are sleepless or if he gets sleep he is not refreshed by it. His face becomes thin or appears bloated, his tongue is white and he suspects that he has fever. If he come under observation at this time his pulse will be found quicker than it should be, there will be the history of pains in the head and chest; and there will be a tendency toward swelling of the legs, though the urine is apparently normal. There is no sensible alteration in the action of the abdominal viscera, except that the bowels are more sluggish than usual. To this description, Good adds that the patient sometimes feels pains shooting over different parts of the body, conceived to be rheumatic, but without the proper character of rheumatism; and sometimes the headache is accompanied with vertigo. Toward the close of the disease, when it terminates fatally, the stomach seems to lose all its powers; the frame becomes more and more emaciated; the cellular membrane in the lower limbs is laden with fluid; there is an insurmountable restlessness by day and a total want of sleep at night; the mind grows torpid and indifferent to what formerly interested it; and the patient sinks at last, seeming rather to cease to live than to die of a mortal distemper.

Such is the ordinary course of this disorder in its simplest form when it proves fatal; and the powers of the constitution are incapable of coping with its

influence. Yet it is seldom that we have an opportunity of observing it in this simple form, and never perhaps but in a patient whose previous life has been entirely healthy and whose mind is unruffled by anxiety. For if this complaint, whatever be its cause, should show itself in a person who is already a prey to grief or care or mental distress of any kind or in whom some one or more of the larger and more important organs of the body, as the liver, the lungs, or the heart, has been weakened or otherwise injured by accident or irregularity or is influenced by a gouty or other morbid diathesis, the symptoms will assume a mixed character, and the disease be greatly aggravated. It is these accidents indeed that for the most part constitute the exciting cause as well as the most fearful auxiliary of the disease; for without such, it is highly probable that the predisposition might remain dormant and that many a patient who falls a sacrifice to it would be enabled to glide quietly through the sequestered vale of age to the remotest limit of natural life and at length quit the scene around him without any violent struggle or protracted suffering, with a euthanasia sometimes though rarely attained but ardently desired by us all.

There are some events that apply equally to both sexes and which very frequently lead to this affection, such as the loss of a long-tried and confidential friend; of a beloved or only child; or of a wife or husband assimilated to each other in habits, disposition, general views and sentiments by an intercourse of perhaps thirty or forty years' standing. This last is a more marked and more frequent cause of excitement than any other, and in some instances it operates very rapidly.

Occasionally, however, where the climacteric temperament is lurking, a very trivial accidental excitement proves sufficient to rouse it into action. "I have known," says Sir Henry Halford, "an act of intemperance where intemperance was not habitual, the first apparent cause of it. A fall which did not appear of consequence at the moment, and which would not have been so at any other time has sometimes jarred the frame into this disordered action. A marriage contracted late in life has also afforded the first occasion to this change."

The treatment, aside from attention to the prevailing arteriosclerosis and concomitant pathological conditions, resolves itself largely into the observation of the rational rules of hygiene, securing proper rest and exercise for the mind and body, adapting the diet to the needs of the body, and possibly the use of tonics. Emerson very aptly observed that a man at sixty must take in sail. Osler's popularly famed euthanasia recommendation was rather an attempt to induce young men to begin trying actually to do something before the prime of life passed. However, a man's duty to himself will impel him, in many instances, to devote his energies to the care of himself at the time of the great climacteric, and later he will devote his renewed strength to the welfare of the community rather than to any selfish end. There is no better tonic ofttimes than thinking and working for the betterment of others. No man is justified in considering his life's work done so long as he lives. There is always important work to be done.

GEORGE E. MALSBARY.

**Climate.**—The word climate comes from the Greek word κλίμα, an inclination or slope. It was applied anciently to signify the supposed horizontal obliquity of the surface of the earth from the equator to the pole. The earth was divided by the earlier astronomers and geographers into parallel climates, or zones, that differed successively from each other from the equator to the pole by some arbitrary increment in the length of the midsummer days. Indirectly these zones, or climates, marked out more or less accurately the gradual changes in the characteristics of the weather dependent upon decreasing insolation. In modern usage the word climate has reference to the weather of a place or region, and to the factors that cause the weather to differ in different regions. It is difficult to give a rigid definition of the modern acceptation of the word climate, because different meanings have been given to it by different writers, just as different conceptions of its scope or the intents and purposes of its users have dictated. As used subsequently in this article the word climate is applied to the totality of those physical conditions of the atmosphere of a place or region that recur with more or less uniformity with the recurrence of the natural periods of time. Or, in other words, climate is the totality of the weather of a place or region as experienced there in the course of a long period of consecutive years. Weather itself is the instantaneous condition of the atmosphere with respect to its physical state. In a more extended sense weather is the continuity of the successive variations in the physical conditions of the atmosphere. In this sense, it is common to speak of the weather at noon, sunset, or any other time of the day, or of the weather of the whole day, or of the month, or of the year, and even of several years in succession.

The investigation of the causes that produce the weather and of their laws and principles of operation constitutes the branch of science known as meteorology. The further study of these causes to find out and classify those that are operative in producing the more or less periodical recurrences of the weather constitutes what is known as climatology, or the science of climate. Climatology is dependent upon meteorology, and meteorology in turn derives benefit from the advancement of climatology. For descriptive purposes, climate is usually stated in terms that have reference or regard to the temperature of the air, its humidity, motion, density, transparency, and electrification; also to the amount of precipitation, that is, the quantity of rain, snow, hail, sleet, dew, and frost, that occurs, and to its distribution: these items are referred to as the climatic elements. The conditions that cause variations in the intensity of the climatic elements constitute the climatic factors; the principal ones of which are latitude, altitude, distribution of land and water, mountain ranges, ocean currents, prevailing winds, amount and distribution of rainfall, nature of the soil and its drainage and vegetation, and the slope of the surface. These factors may be classified as fixed or natural factors, and dependent or resultant factors. The fixed factors are altitude, latitude, distribution of land and water, mountain ranges and slope of the surface, and nature of the soil; the dependent or resultant factors are the ocean currents, the prevailing winds, precipitation, soil drainage, and vegetation. As different regions and places on the earth's surface differ with respect to one or more of these factors, the climates of such regions necessarily differ more or less from each other. To describe exactly the climates of the different regions of the earth would be a task too great to be undertaken, but fortunately such exactness is not necessary to a practical comprehension of the climatic possibilities of any given spot on the globe.

Certain important principles are learned from meteorology that go far toward enabling us to anticipate from the geographical position and natural features of a place relative to some other place, whose climate is known, what the climate of the former is likely to be. Primarily, climate results from the effects on the earth's surface of the incident solar energy and its unequal distribution, which follows of necessity from the shape of the earth and its motions and its inclination with respect to the ecliptic. Other disturbing causes are introduced by the heterogeneous nature of the earth's surface. All of these causes have been alluded to as the climatic elements and factors. Their actual operations and effects will become plainer

if we first consider a hypothetic earth and sun. From the laws of general physics, we can predict with as much certainty as we can predict the future course of the earth in its orbit what would be the climatic conditions upon every part of our imaginary globe. Starting with a homogeneous, smooth spheroid, either land or water, having an atmosphere of the same composition as our actual atmosphere, situated with respect to its sun as the actual earth is to its sun, only having no axial revolution, the sun revolving round the earth instead, let us consider what kind of climate it would have. The amount of solar energy received on each and every meridian of our hypothetic earth would be distributed from the equator to the poles in a ratio that would vary approximately as the cosine of the latitude (this is also true with regard to the actual earth, and is an important fact to bear in mind); the temperature of its atmosphere would therefore decrease gradually poleward on each side of the equator and every place on the same parallel of latitude would have the same temperature.

As the temperature controls the amount of moisture in the atmosphere, places on the same parallels would have the same degree of atmospheric humidity. The same conditions of equality would be true, also, of the winds and their velocities. In short, the climate of a given spot would be determined by its latitude, and all places in the same latitude would have the same climate. The general circulation of the atmosphere would be simple. The warmer air of the equatorial zone would expand, rise to a higher vertical level, and flow off toward the cooler poleward regions. The air of these regions, under the difference of pressure that would result from the accumulation of the overflowing air from the equator, would flow equatorward. This polar air, however, arriving in the equatorial zone would itself be warmed, expanded, and would overflow in like manner; and so a circulation would be established with surface currents from the poles to the equator, and upper currents from the equator to the poles, the direction of both currents being along the meridians. This would be the general tendency of the circulation. The actual circulation would be somewhat more involved. From the form of the surface of the spheroid over which this circulation would take place, the poleward moving air would be banked up more or less in its course by the lateral diminution of the area over which it was moving. By giving proper consideration to the mass of moving air to the diminution of the area over which it is moving, we can determine that the maximum banking up of the poleward currents would take place about latitudes 30°, north and south. The result that would follow this banking up would be an increase in atmospheric pressure in these regions with surface outflows on each side, those on the equatorial sides toward the equator, as in the first hypothetic instance; those on the polar side toward the pole, and opposite and antagonistic to the flow in the first supposititious instance. The result of this opposite poleward flow would be to overcome for a considerable distance the surface currents from the poles; the latter would be lifted from the surface and become middle currents. This underrunning and lifting of the polar currents would obtain to about the polar circles. The final result would be surface winds on the equatorial sides of latitude 30° toward the equator, and on the polar sides toward the poles; surface winds within the polar circles toward the equator; regions of variable winds and calms at the equator, latitudes 30°, and the polar circles. The circulation, however, would still be along the meridians.

If, now, our hypothetic earth and sun assume relations to each other like those of the actual earth and sun, a decided modification of this imaginary atmospheric circulation would take place. From the axial rotation of the earth, there would arise a right-handed deflecting force in the northern hemisphere and a left-handed deflecting force in the southern hemisphere. In the northern hemisphere, north winds would be deflected to the right and become northeasterly winds, and south winds would be deflected to the right and become southwesterly winds. (A wind is named from the direction from which it comes; *e.g.* a northeast wind is one that comes from the northeast.) In the southern hemisphere, northerly winds would become northwesterly,and southerly winds would become southeasterly. And now on our imaginary spheroid there would be a system of atmospheric circulation such as is shown in Fig. 1439. Subject to the interferences introduced by the land and water surfaces and the irregularities of elevation of the former, this imaginary circulation is the actual

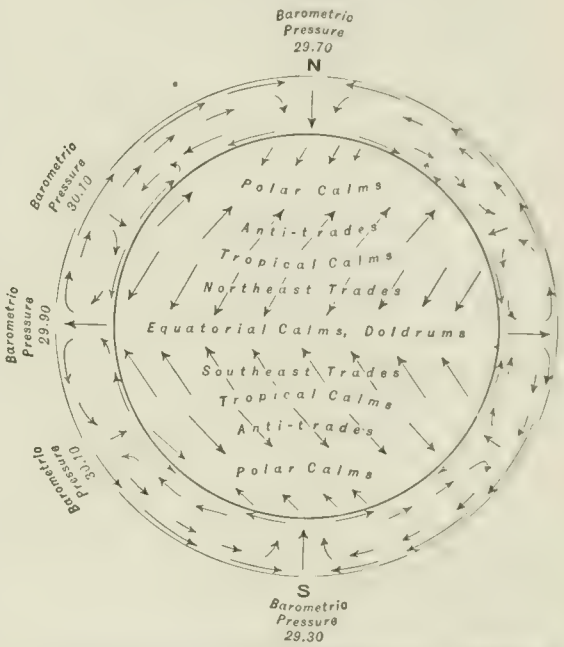



Fig. 1439.—Showing General Circulation and Direction of Atmospheric Currents. (After Ferrel.) Arrows in inner circle show the direction of the surface winds. Arrows between inner and outer circles show the scheme of the vertical circulation.

circulation on our real earth. Bearing in mind the atmospheric conditions that would exist upon a homogeneous and smooth earth, we are prepared to see how these conditions are modified by the heterogeneous surface of our actual earth, and how the climate of any place is controlled by and may be predicted with more or less certainty from a knowledge of what we have called the climatic factors.

Climatic Factors.—The general effect of these factors will now be briefly described.

*Latitude.*—Generally speaking, at the equator the sun's rays at midday fall perpendicular to the surface of the earth and their intensity is at maximum. North and south of the equator they impinge at angles that increase with the latitudes and they lose in intensity from two causes: first, because they are spread over a larger surface; and secondly, because they traverse a greater depth of air and lose energy from atmospheric absorption. With some slight modifications this explanation is applicable to the differences between the intensity of insolation at noon and that at other hours of the day. Figure 1440 will illustrate these two facts. The same beam R, when the sun is vertical, is spread over a surface such as FF. When the sun is inclined at an angle as represented in the figure, the beam is spread over a

surface F′F′, which is obviously greater than the first, and it passes through a column of air A′A′F′F′ greater than that of AAFF.

The intensity of insolation at midday decreases approximately as the cosine of the latitude. If the

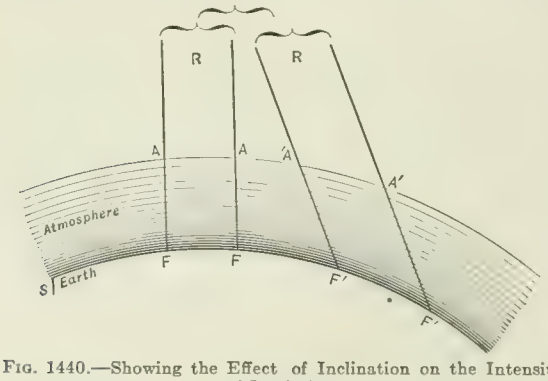



Fig. 1440.—Showing the Effect of Inclination on the Intensity of Insolation.

solar radiation received in the average day at the equator be taken as unity and be called a thermal day, the annexed table will show the annual sum of solar radiation received at different latitudes:

| Latitude. | Thermal days. | Latitude. | Thermal days. |
|---|---|---|---|
| 0 | 365.2 | 50 | 249.7 |
| 10 | 360.2 | 60 | 207.8 |
| 20 | 345.2 | 70 | 173.0 |
| 30 | 321.2 | 80 | 156.6 |
| 40 | 288.5 | 90 | 151.6 |

The amount of solar radiation also depends upon the length of the day. At the equator the days are practically of the same length and there is virtually no variation in the daily or seasonal amounts of insolation; but toward the poles the variation in the length of the day becomes very great, so much so as to overcome at certain seasons of the year the adverse effect of latitude. The following table shows the intensity of solar radiation on the 16th of December, the 16th of March, and the 16th of June, dates near the shortest, the average, and the longest days of the year, for each 10° north latitude. The figures express the intensity as a percentage of what it would be were the sun to remain vertical for twenty-four hours.

| North latitude | 0°. | 10°. | 20°. | 30°. | 40°. | 50°. | 60°. | 70°. | 80°. | 90°. |
|---|---|---|---|---|---|---|---|---|---|---|
| December 16. | 30% | 26% | 22% | 17% | 12% | 6% | 2% | .... | .... | .... |
| March 16.... | 32% | 31% | 30% | 27% | 24% | 20% | 15% | 10% | 6% | .... |
| June 16..... | 28% | 31% | 33% | 34% | 35% | 35% | 35% | 36% | 38% | 38% |

The eccentricity of the sun with respect to the center of the earth's orbit is such that at the period of perihelion the effect of the solar energy is about seven per cent. more than at aphelion. As perihelion occurs in the summer time of the southern hemisphere, and aphelion in its winter, the seasons are much more extreme in that hemisphere than in the northern.

*Altitude.*—In climatology, altitude signifies vertical height above the level of the sea. The effect of altitude upon climate follows from its effect upon the mass of the atmosphere. According to the well-known law of Boyle, the volume of a given mass of gas will vary inversely as the pressure for all ordinary ranges of pressure, the temperature remaining constant. The stratum of air at 3.5 miles above the sea sustains only about one-half the sea-level pressure; accordingly, if the temperature remains constant, a given volume of air at the level of the sea if transported to this altitude would expand into two volumes. Conversely, a volume of air at this altitude would be compressed at sea level into but half its original volume. Under natural conditions when air expands freely, that is, without doing work, it loses temperature, or, more correctly, its heat is employed in accomplishing the expansion, and becomes latent to the senses and to the thermometer. The opposite is the case when air contracts without doing work: that is, it gains in temperature, or it liberates the heat that was doing the work of expansion; this liberated heat becomes sensible. Alterations of the temperature of the air of this sort are spoken of as adiabatic cooling and heating; *i.e.* cooling and heating without loss or accession of heat from outside sources.

The general effects of altitude upon the air may by briefly stated, with approximate accuracy, to be that the volume of a given quantity of air increases and its density decreases with the altitude; it decreases in temperature and loses more or less of its humidity by condensation and precipitation; its velocity increases, but its relative momentum decreases, it is more transparent, and offers less obstruction to insolation. The percentage composition remains unchanged, with the exception of the moisture as above stated. The following table shows the approximate decrease in atmospheric pressure for each 1,000 feet up to 10,000 feet.

| Elevation above sea level (feet). | Barometric pressure (inches). | Elevation above sea level (feet). | Barometric pressure (inches). |
|---|---|---|---|
| 0 | 29.97 | 6,000 | 24.07 |
| 1,000 | 28.92 | 7,000 | 23.20 |
| 2,000 | 27.88 | 8,000 | 22.37 |
| 3,000 | 26.87 | 9,000 | 21.56 |
| 4,000 | 25.90 | 10,000 | 20.79 |
| 5,000 | 24.97 | | |

*Land and Water.*—These two forms of the earth's surface are the perturbing factors of climate. As already pointed out, a homogeneous, smooth earth would have regularly distributed climatic conditions. The introduction of two kinds of surface, distinct in form and properties, and irregularly distributed with respect to each other, and in the case of the land irregular in its own surface, produces all the anomalies encountered in climate. A knowledge of the land forms and the relative positions and distributions of land and water is essential to the understanding of the actual climates of the earth. The disturbing influence of the land and the water surfaces of the earth arises from the different specific heat capacities of these two surfaces and their different powers of conduction, convection, and radiation of radiant solar energy; also, from the rigidity of the one and the mobility of the other; and the general persistency of form in one, the land, and the duality of form (liquid and vapor) in the other, the water. Some of the effects caused by the irregularities of the land surface have been alluded to under altitude, and others will be mentioned under other heads. The specific heat capacities of land and water are about in the ratio of 1 to 4, that is, the same absolute amount of heat will raise the temperature of a land surface four times as high as it will raise that of a water surface. Land is a poor absolute conductor and a poor reflector of heat; it is a good absorber and a good radiator. From its poor conductivity the land retains its absorbed heat near its surface to be as quickly radiated as it was absorbed. Water is a fairly good reflector, and for this reason a considerable quantity of the incident insolation is reflected and exerts no influence upon the temperature of the water. Water permits a

considerable part of the incident heat to penetrate it to a not inconsiderable distance. Comparatively little of the heat is absorbed by the immediate surface layer or by any other one layer; the absorption is distributed almost uniformly throughout the depth penetrated. A part of the heat absorbed is expended in evaporating some of the water, and causes no rise in the temperature of the water. The water is in continual motion, and so a further mixing of the layers at different temperatures and depths, and of the waters of different regions, takes place. The warm water in the equatorial regions, heated by the intense insolation of a vertical sun, flows poleward along the surface, and its place in the torrid zone is taken by the cooler waters from higher latitudes that flow equatorward as deep currents. The specific heat of water is great, greater than that of almost any other substance, hence it requires a great deal of heat to cause a perceptible increase in its temperature; *per contra*, it may radiate a great deal of heat without sensibly lowering its temperature. From the operation of all these factors, a water surface maintains a more uniform temperature than does a land surface. It is never as hot in the summer and never as cold in winter. A certain amount of evaporation takes place from all land surfaces not absolutely dry; but the amount is extremely small compared with the distillation that goes on from a free water surface. As a consequence, the atmosphere over the latter contains always more moisture (the temperature being the same) than the former, and clouds and precipitation are more frequent as a rule.

*Mountain Ranges.*—The influence of mountain ranges is seen chiefly in their effects upon the rainfall and the prevailing winds. These effects will be more or less general or local according to the height and direction of the mountains with reference to the general atmospheric circulation of the latitude. If a range runs transversely to the prevailing winds, it will either deflect them from their course or force them into higher altitudes. In the former case the range will serve as a wind break to the regions on its lee side and will send the winds into other regions from directions other than they would have come. Most important consequences arise from this fact. The late distinguished American meteorologist, Prof. William Ferrel, has pointed out that the high tablelands and mountains of Mexico deflect the winds of the northeast trade zone toward the north over the southeastern United States and up the Mississippi valley into higher latitudes. "This," says he, "completely breaks up the tropical calm belt and dry zone, so that instead of a dry region with scanty rainfall, such as is found in North Africa, Arabia, etc., . . . we have a region of abundant rainfall, and all the way up the Mississippi valley and in the interior of the continent there is much more rain than in the interior of Asia." When a wind is forced up a mountain it cools by expansion, or adiabatically, and more or less of its moisture is precipitated on the mountain sides and top. On the lee side of the mountain it descends and its temperature is raised by compression, again adiabatically. As the air in its passage up the mountain has lost the greater part of its moisture by precipitation, in its descent on the lee side of the mountain its temperature is raised to a higher point than it was at the beginning of the ascent, because dry air has a less specific heat capacity than moist air. These facts are seen in the well-known phenomena of the Swiss *Föhn* and the American *chinook* winds. Mountain ranges that do not obstruct the prevailing winds of the region exert only local influences upon the climate of the region.

*Ocean Currents.*—The effect of ocean currents on climate may be inferred almost without further comment from what has been said regarding the difference of insolation on land and water surfaces. The chief effect of ocean currents is to temper the extremes of the shores that they wash, and this tempering effect may extend to a greater or lesser degree inland, depending on the greater or lesser elevation of the land near the coast and the prevailing winds of the region. The most notable illustration is seen in the effects that are popularly attributed to the Gulf Stream, but which are really those of the general circulation of the North Atlantic Ocean. By this circulation the warm water from the tropics is carried northeastward to the shores of Iceland and Northern Europe, rendering habitable, by the aid of the winds of those latitudes, which blow from the ocean, countries that would otherwise be as bleak as Labrador. The better-known ocean currents are the Gulf Stream of the North Atlantic and the Kuro Siwo of the North Pacific, both warm currents, flowing from the tropics toward the cooler waters of the poleward regions. There are other warm currents less popularly known flowing from the tropical waters. There are also cold currents from the Arctic regions that chill the coasts of the countries they wash. A cold current flows from Davis Strait along the coast of Labrador and even farther southward, influencing the temperature of the coast as far as Cape Cod. Humboldt's, or the Peruvian, current from the Antarctic lowers somewhat the temperature of the Chilian littoral.

*Prevailing Winds.*—As climatic factors the prevailing winds are the agencies by which the inequalities in temperature and the other climatic elements that result from the effects and distribution of the land and water surfaces of the earth are maintained within a measure of equilibrium, which though varying in different regions, yet remains on the whole constant for each region. To understand the climate of a region, the direction from which the wind of that region comes must always be taken into consideration. If the wind comes directly from over a considerable body of water, it will bring with it, in a greater or lesser degree, the temperature and humidity of the air over the water surface. Should, however, a mountain range intervene, the wind would be robbed of the greater part of its moisture, but would retain its temperature, as already referred to under the effects of mountain ranges. On the other hand, if the wind blows from the land, it brings with it the climatic conditions of the surfaces which it traverses.

Winds are classified as permanent, periodic, and variable. The permanent winds are those of general systemic circulation that prevail over the disturbing effects of the land and water distribution. They are well represented in the trades and the antitrades of the oceans. The periodic winds are characterized by their prevalence from one direction in one season, and from the opposite direction in the opposite season. The Indian monsoons are the most popularly known of this class. The variable winds are members of the cyclonic and anticyclonic circulation systems of the atmosphere. The prevailing winds of a region can be predicted from a knowledge of the position of the region with respect to the general system of the atmospheric circulation, previously indicated, and from the relative position and distribution of the land and water areas of the region, the topography of the region and the consideration of the season of the year, and, in some instances, of the time of the day. From the facts already developed of land heating and cooling more rapidly and more extremely than water, the atmosphere over the land is subjected to greater extremes of temperature and density than that over the water. Air moves in the direction of least resistance, that is, from the denser toward the less dense. In the case of continents these conditions give origin to the class of periodic winds known as monsoons, from the Hindoostanee signifying season. The monsoon results, in the summer, from the overheating of the air over the interior of a continent, its consequent expansion, loss of density, rising and overflowing as upper air currents toward the cooler region of the

ocean and the inflowing as surface currents of the cooler air from the water to take the place of the former. This form of exchange keeps up during the summer months. In the winter months the conditions are reversed. The air over the ocean is warm, that over the interior of the continent cold, for reasons that have been explained, and the exchange takes place just the opposite of that in summer. When the monsoon wind is in the direction of the general circulation of the latitude, it adds its force to that of the latter, which appears as a stronger wind than normal. If contrary, the monsoon must either overcome or be overcome by the general wind of the latitude. If the first, it appears as a feeble monsoon; if the latter, it is in evidence negatively as an enfeeblement of the systemic wind of the latitude. The effects of topography upon a monsoon can be inferred readily from what has been said regarding the influence of mountains on winds. Along the littorals of all large bodies of water a familiar illustration of the different effects of insolation on land and water is seen in a periodic wind of shorter period than the monsoon, the daily land- and sea-breeze.

The following broad generalizations as to the prevailing winds, and also ocean currents, of the globe may be of service. Within the warmer latitudes, the tropics and subtropics, the winds and ocean currents have a prevailing direction from the east; within the temperate latitudes, the winds and ocean currents have a prevailing direction from the west; within the polar latitudes, the wind and ocean currents have a prevailing direction from the poles toward the equator. There are a few winds that should be mentioned because of the frequent reference to them in climatic literature. These winds are all cyclonic in origin. The disagreeable *east wind* of Britain, referred to so often by Dickens in one of his novels, is dry and cold. The *mistral* of Southern France is a violent cold, dry, northwest wind, and is the *tramontana* of the Adriatic coast. The *northers* of Texas and the West are very cold and dry winds. The *scirocco* of the Mediterranean littoral is a torrid south wind, hot from the sands of the Sahara and damp from the moisture of the Mediterranean. The *khamsin* of Egypt, and the *harmattan* of the west coast of Africa, are easterly and southeasterly winds, dry and hot from Sahara. The dreadful *simoons* of the Arabian and Persian deserts are but violent local whirlwinds, mixing the air and the heated sands of the desert together, with resultant temperatures that would be unendurable if continued longer than a few moments. The simoon passes over in about ten minutes.

*Rainfall.*—The effect of rainfall as a factor is rather passive than active. Rain itself is the result of the operation of the other climatic factors and elements. To save a certain amount of repetition, its further consideration is deferred to rain as an element of climate.

*Soil.*—The nature of the land surface, apart from the great irregularities that have been considered under mountain ranges, exerts a considerable influence upon the climate of the region. The physical construction and chemical composition of the soil affect in no inconsiderable degree the quantities of insolation and of moisture that remain for a greater or lesser time in its surface. The general relation of the kind of soil to the absorption and radiation of heat is approximately about as follows:

Absorption and Radiation of Heat in Percentage.

| | |
|---|---|
| Sand, with some limestone | 100 |
| Pure sand | 96 |
| Light clay | 77 |
| Gypsum | 72 |
| Heavy clay | 71 |
| Clayey earth | 68 |
| Pure clay | 67 |
| Fine chalk | 62 |
| Humus | 49 |

From this table it will be observed that a sandy limestone soil absorbs practically all the heat falling on it. The absorptive and the emissive thermal powers of a body being equal, it follows that the same soil radiates under given conditions all the heat it absorbs. Observation has shown that sandy deserts are subject to the greatest ranges in temperature. Earth containing much humus shows less range of temperature than any other kind of soil. The quantity of moisture taken up by the different kinds of soil varies greatly. Sand and sandy soils absorb moisture quickly and in great quantity, but retain it badly. Humus may take up from forty to sixty per cent. of its own volume of water and will retain it strongly. Rain falling, therefore, on sandy soil is quickly absorbed and quickly lost, the loss is mostly by percolation; falling on humus it is slowly absorbed, but what is taken is strongly retained. The damper the soil the more nearly it approximates the behavior of a water surface with respect to temperature and humidity. Frost does not form readily on marshy lands, while on well-drained lands it may occur on any night that the atmospheric temperature falls to 40° F. The damper the soil, the damper will be the atmosphere over it; the drier the soil, the drier the atmosphere—that is, so far as the moisture content of the air is dependent on the evaporation from the soil. Drainage of the soil will raise the temperature in the day and lower it at night. Water-logging will restrict both the day and the night ranges. Vegetation, though not strictly a part of the soil, is intimately associated with the latter and may be considered in connection with it. The effect of vegetation will depend upon whether it simply covers the soil as grass, or extends above and shades it as forest. The general effect of vegetation is to cool the soil by affording an increased radiating surface. Only a relatively small part of the foliage surface of plants is exposed to the sun's rays and absorbs heat, while all the foliage surface radiates heat; hence, the lower temperature of vegetation compared with that of the soil. In grass-covered fields the night temperature falls lower than in the forests; this is undoubtedly due to the interference with soil radiation by the elevated foliage. The average temperature, however, of forests is lower than that of woodless plains, but the temperature variations are less. The average humidity of the air of forests is usually about four to five per cent. above that of the open. The effect of forests upon rainfall is a much debated question. The weight of statistical evidence is that rainfall is neither increased nor decreased by the presence or absence of forests. Floods, so often attributed to deforestation, are due solely to excessive and prolonged rainfall over the drainage basin of the stream, or to rapid thaws when snow in quantity covers the basin, or to rain and thaws combined. Forests may serve to a certain extent as wind breaks. These influences are obviously local in operation. The effect of forests on the climate of a region in general is a matter awaiting further inquiry. The local slope of the ground has a considerable influence on the local climates of a region. A hillside sloping toward the sun receives the solar rays more nearly vertically than one sloping away from the sun. As a consequence the surface temperature of a sunward incline will be higher than that of an antisolar incline. The effect of inclination upon soil drainage is obvious and needs no comment.

Climatic Elements.—The items, or elements, of climate will now be considered briefly in detail.

*Pressure.*—Atmospheric pressure, though of the utmost importance in the causation and the explanation of the general and the local circulation of the air, is not usually classed among either the climatic factors or the climatic elements. It is not a climatic factor in the sense that latitude, altitude, land, and water

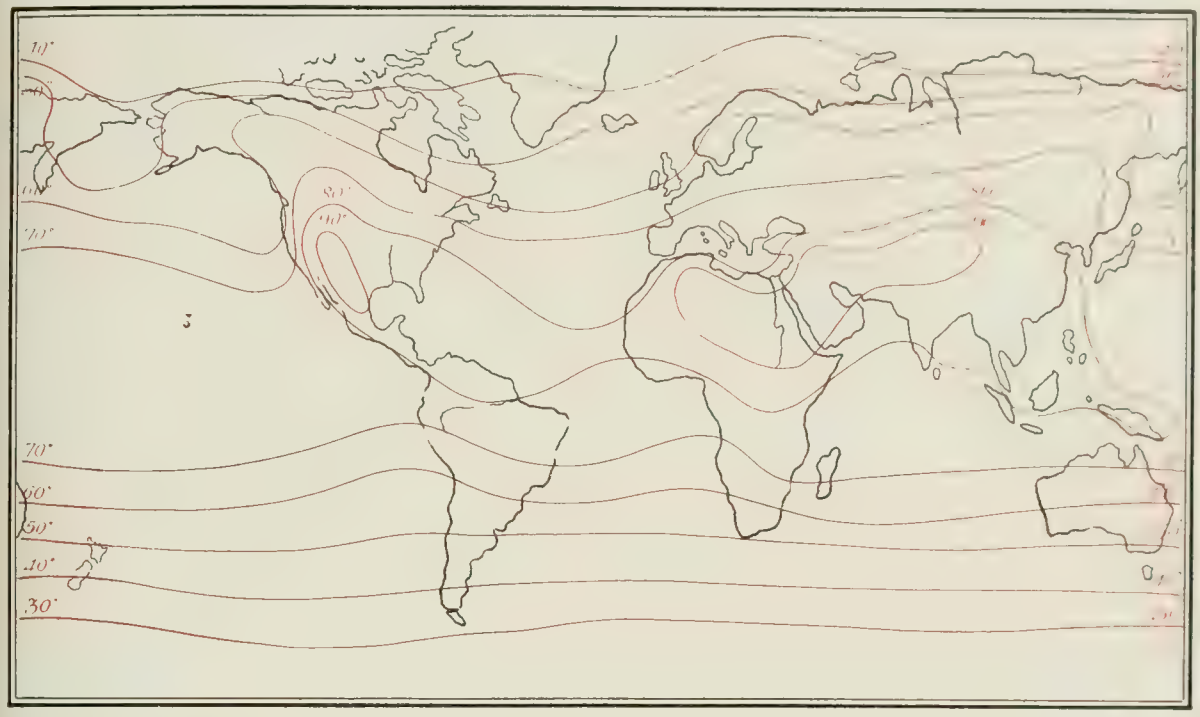



Fig. 1.

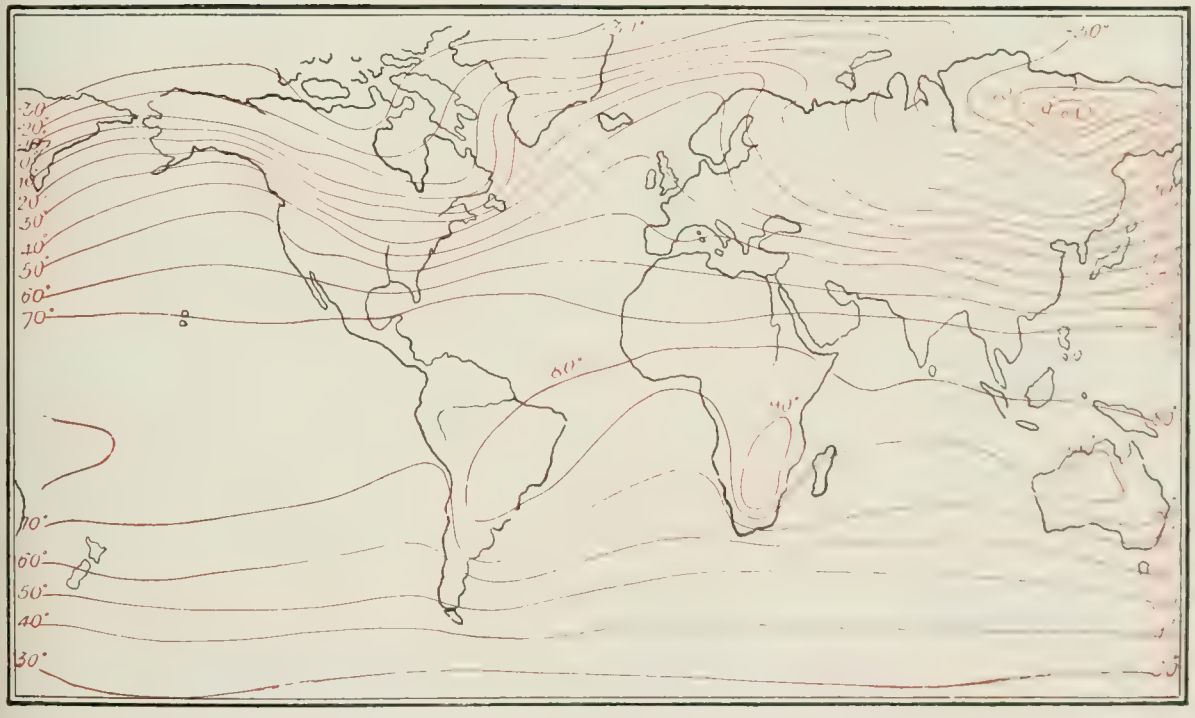



Fig. 2.

## CHART OF ISOTHERMS OF THE WORLD

Degrees Fahrenheit

Fig. 1, for July; Fig. 2, for January.

are, because it has nothing of their fixity. As an element of climate it is not perceptible to the senses like temperature, moisture, and the other climatic elements, hence it is generally left out of this category. Whether factor or element or neither, it is, however, a matter of importance to the student of climatology to know something of the general distribution and effects of atmospheric pressure. In the introduction to the general atmospheric circulation, the statement was made that in the region of latitude 30°, both north and south, there resulted from the banking up of the poleward moving currents a belt of high pressure that was sufficiently great to cause a poleward out-moving current at the surface strong enough to overcome the equator-seeking surface current from the poles. The pressure in this belt (speaking now of the one in north latitude) is not uniformly distributed around the earth. In winter, the pressure is greatest in those portions of the belt that cross the great continental areas of America, Europe, and Asia, and lowest in those over the Atlantic and Pacific Oceans. In summer, the pressure is greatest in those portions of the belt over the Atlantic and Pacific Oceans and lowest in those over the continents. This shifting of pressure gives rise to the monsoon winds; it is itself due to the unequal effects of insolation on land and water. In the southern hemisphere these changes are less striking, because of the relative preponderance in area of the water over the land, but they are still in evidence. As a climatic element the pressure changes from day to day are usually so slight that their effects escape detection except by closest observation. To a certain extent the effects usually attributed to altitude are those that belong properly to diminished atmospheric pressure.

*Temperature.*—If other influences be ignored, it may be stated that the temperature is highest under the vertical sun and decreases as the sun declines from the vertical. The rate of this decrease with regard to latitude has been explained and is, as previously stated, approximately as the cosine of the latitude. If we read altitude for latitude, the same ratio will hold good for the intensity of the insolation with a clear sky at any hour of the day. When the sun is just on the horizon its rays are tangent to the surface, and practically all its caloric radiant energy is absorbed by the great depth of the atmosphere through which the rays have to pass. As the sun rises above the horizon this depth of atmosphere becomes less and less, in the ratio stated, and less and less heat is absorbed, till under a vertical sun seventy-five per cent. of radiant energy, as heat, reaches the earth's surface. As the sun declines from the vertical the reverse operation takes place. Under the equator, or within the tropics generally, it is estimated that on a clear day sixty-five per cent. of the total radiant solar energy incident on the outer limits of the atmosphere reaches the earth's surface. From the different effects produced by the solar rays on land and water, taken in connection with the great increase in the length of the summer day (that is, of the time the sun is above the horizon) in the higher latitudes, one is prepared to understand that the highest temperatures are not necessarily confined to the tropics. The lengthened sunlighted day of the summer in extra-tropical regions, and the relatively great absorption of heat by the land, cause the temperature of the continents in these regions to be from 10° to 20° F. higher than the theoretical normal for their latitudes. On the contrary, the long nights of these regions in winter and the enfeebled insolation due to the low meridian altitude of the sun, and also to the great radiating powers of the land, bring the temperature of these continental areas correspondingly below their theoretical normals. The following table, calculated by the late Prof. William Ferrel, shows in F. degrees the average temperature over the combined land and water surface for each tenth parallel as far as 80° north and 60° south latitude, for January, July, and for the year.

| Latitude. | Temperature. | | |
|---|---|---|---|
| | January. | July. | Mean of Year. |
| North 80° | −25° F. | 34° F. | 4° F. |
| North 70° | −16 | 44 | 14 |
| North 60° | −2 | 57 | 29 |
| North 50° | 21 | 66 | 43 |
| North 40° | 40 | 73 | 56 |
| North 30° | 55 | 80 | 68 |
| North 20° | 71 | 84 | 78 |
| North 10° | 79 | 83 | 81 |
| 0° | 81 | 79 | 80 |
| South 10° | 82 | 75 | 79 |
| South 20° | 80 | 69 | 75 |
| South 30° | 73 | 60 | 67 |
| South 40° | 64 | 52 | 58 |
| South 50° | 52 | 44 | 48 |
| South 60° | 38 | 32 | 35 |

The approximate actual distribution of temperature around the world for January and July, as deduced from the accumulated meteorological records of the world, is shown in the two accompanying charts (Plate XXVII). A comparison of the deflection of the actual isotherms from the position of the calculated isotherms shows most strikingly the effects of the different climatic factors. The influence of the ocean currents and the general heat-retaining properties of water cause the extratropical parts of the great oceans to be from 5° to 10° F. cooler in summer than the calculated normals for the latitudes, and from 10° to even 40° F. warmer in winter, as in the North Atlantic. The interior of continents is subjected to the greatest extremes of heat and cold, while the temperature of their shores may be greatly modified by that of the surrounding oceans. Though many irregularities exist in the falling-off of temperature with increasing latitude, nevertheless the decline is positive. But latitude is not alone necessary for low temperature; even under the equator, if the elevation be sufficient (about 15,000 feet), freezing temperatures and snow may be found. Going toward the poles this elevation declines until at the Arctic circles it is at sea level. The line of the altitudes of this freezing temperature in the different latitudes is called the snow line. In the free air, the temperature falls about 1° F. for every 300 feet ascent. In ascending high mountains, the decline is slightly less. Over elevated plateaux the fall in temperature due to the altitude of the region is very much less, not more than 2° to 3° F. to the thousand feet, and this amount varies with the season, being less in summer and greater in winter. In estimating, therefore, what will be the decrease in temperature due to the altitude of a place, regard must be had to whether it be a rapidly rising mountain or a slowly rising plain.

The temperature of the air is controlled more or less in its degree and in its fluctuations by the state of the atmospheric humidity. Water in the gaseous state is as diathermanous as dry air; but when condensed as cloud, even though the condensation be too slight to be visible, it offers great obstruction to the passage of heat. Hence in cloudy regions, and on cloudy days, the temperature is usually more uniform, that is, it is subject to less pronounced extremes of heat than it is in clearer regions or on cloudless days. Air expands or contracts $\frac{1}{491}$ of its volume for each change of 1° F. Warm air is, therefore, lighter and rises; cold air is heavier and falls. The effect of this is seen in the phenomena of hill and valley winds. In

the daytime the warm air flows up the hillside, and at night the cool air flows down the slope into the valley, where it is felt sometimes as an intensly cold wind. These cold night winds are very common in the deep valleys of the Swiss Alps. The average temperature of the air is highest both seasonally and diurnally, not at the time of the greatest solar altitude, but at a period a little subsequent thereto. The warmest part of summer is about a month after the estival solstice; and the warmest part of the day is about one or two hours after noon. The coldest part of the winter is about a month after the winter solstice, and the coldest part of the day is about an hour before sunrise.

*Humidity.*—The relation between temperature and humidity is an intimate one. The amount of water that can exist in the gaseous state depends on the temperature. The higher the temperature the greater the possible humidity; the lower the temperature the lower the possible humidity. Water exists in the gaseous state at all observed temperatures. The following table shows the actual weight of water that can exist as a gas at some of the ordinary atmospheric temperatures:

| Temperature. | Number of grains of aqueous vapor in a cubic foot. | Temperature. | Number of grains of aqueous vapor in a cubic foot. |
|---|---|---|---|
| 100° F. | 19.8 | 30° F. | 1.9 |
| 90 | 14.8 | 20 | 1.2 |
| 80 | 10.9 | 10 | .8 |
| 70 | 8.0 | 0 | .5 |
| 60 | 5.7 | −10 | .3 |
| 50 | 4.1 | −20 | .2 |
| 40 | 2.8 | | |

The amount of moisture in the atmosphere in any given locality will be governed, first, by the temperature of the region; secondly, by the nature of the evaporating surface of the place, whether land or water; thirdly, by the rate at which the humidity is carried away; and finally, by the rate at which humidity is brought to the region by the prevailing winds. As the temperature declines with altitude, it is evident that the humidity possibilities of elevation must likewise decline. The humidity of the atmosphere is referred to under two captions, absolute and relative humidity. By absolute humidity is meant the real amount of water existing as vapor in a unit of space. In English measures this amount is stated usually as grains of water per cubic foot. The table just given shows the absolute humidity in a saturated cubic foot at the temperatures indicated. By relative humidity is meant the ratio that the amount of vapor actually present bears to the amount required to saturate the space at the given temperature. Relative humidity is usually stated as a percentage, saturation being taken as 100. Absolute humidity is a physical entity. Relative humidity is simply a relation between the temperature and the absolute humidity. The statement of the relative humidity conveys no practical information unless the temperature or the absolute humidity be given also. The absolute humidity of the air, though limited in its quantity by the temperature, varies but slowly from day to day and from season to season. The variation is less with a rising temperature, because the increase of temperature does not affect in any way the form of the humidity. But as the temperature falls a point is reached when the space will be saturated, and then a change of form of the moisture takes place, condensation occurs, and heat, the so-called latent heat of evaporation, is set free, which raises the temperature somewhat and checks its fall for a while. This process may go on indefinitely till either the moisture be all precipitated or some accidental cause comes in to raise the temperature. This fact of moisture liberating heat during condensation is an important factor in the retardation of cooling. In passing from the liquid to the vapor state, water takes heat from the surroundings, that is, evaporation lowers temperature.

The amount of evaporation depends on the temperature of the space into which the vapor escapes. The higher the temperature of the space the more vapor it can contain. The rate of evaporation depends on the temperature of the evaporating surface, the humidity, and the velocity of the wind. The temperature of the evaporating surface determines the velocity with which the vapor molecules escape from the surface; the higher the temperature the greater the velocity. The lower the atmospheric humidity the more rapidly will the molecules escape into the space, and the higher the velocity of the wind up to a certain limit the more rapidly will the escaped molecules be removed out of the way of others.

It is customary to say that the atmospheric pressure influences the rate of evaporation; this is only true if by it we mean the partial pressure of the aqueous vapor in the atmosphere. Water evaporates in a dry atmosphere of oxygen or any other dry gas under twice the ordinary barometric pressure as rapidly as it does in one of like kind under but one-fourth the same pressure. It is the pressure of the water vapor that controls the rate of evaporation, for the well-known physical fact that all gases are to each other as vacuums holds good with regard to the gases of the atmosphere. The fact that evaporation is usually more rapid in elevated regions is simply due to the lesser atmospheric moisture of these regions. The wind facilitates evaporation by removing the layer of vapor formed over the evaporating surface, thereby lessening the vapor pressure on the surface. Under the most favorable conditions, a certain definite time is required to convert water into vapor. When the velocity of the wind reaches a rate of movement equal to the rate of vapor formation, no further increase in the movement of the wind affects the rate of evaporation. This velocity is about thirty miles per hour; that is to say, wind velocities of more than thirty miles per hour have more effect on the rate of evaporation than a thirty-mile wind has.

The following table shows in inches the average depth of water evaporated annually from a free water surface at several places where such records have been kept:

| Place. | Latitude. | Evaporation. |
|---|---|---|
| Madras | 13 N. | 91 in. |
| St. Helena | 17 S. | 84 in. |
| Dijon | 47 N. | 26 in. |
| London | 51 N. | 21 in. |
| Boston | 42 N. | 39 in. |
| Lake Michigan | 44 N. | 22 in. |
| Great Salt Lake | 41 N. | 80 in. |
| Fort Conger | 82 N. | 9 in. |

The atmosphere contains always more or less foreign solid particles, or dust, which radiate their heat during the night more rapidly than the air. The temperature of many of these particles will generally fall below that of the atmospheric dew-point at the time—that is, the temperature at which the air would be saturated with moisture. As a result vapor will condense upon them, they will become heavier and heavier, and many of them will fall to the ground. The occurrence of this phenomenon explains why the air is, as a rule, so much clearer in the mornings than at other parts of the day.

*Wind.*—The movement of the atmosphere, or simply the wind, results from a difference in the density of the atmosphere. The wind is merely the effort to restore or maintain an equilibrium. The atmospheric density is disturbed in two ways: by difference in temperature and by difference in humidity. The effect of temperature on the density of the air has been mentioned. Aqueous vapor is specifically lighter than either oxygen or nitrogen, the two chief constituents of dry air; hence an equal volume of moist air is lighter than a like volume of dry air, temperature and pressure being equal. The movement of the air is impeded by friction at the surface of the earth; and it increases with elevation up to a certain height.

Atmospheric movement is of two kinds, vertical and horizontal; the latter are those familiar to us as winds. The vertical circulation is, however, an important element. It is by the vertical movement of the air that the uniform ratio of mixture of the different permanent gases of the atmosphere at all observed elevations is maintained. The upward vertical movement is greatest in the region of the equatorial calms. A downward vertical movement takes place in the region of variable winds about latitudes 30°, also in the regions of the poles. (See Fig. 1439.) The winds are generally stronger during the day and increase in velocity up to noon or a little after, and then decrease gradually to a minimum during the night. This does not apply, of course, to the wind velocities of accidental storms.

*Electrification.*—As an element of climate, the electrical state of the atmosphere deserves mention; but as to its effects little can be said. The atmospheric electrification is, as a general rule, positive with respect to that of the earth, but it is subject to great and sudden variations. During rain storms the atmosphere is often if not generally negatively electrified. There appears reason to think that the atmospheric potential of elevated regions is greater than that of sea-level regions.

*Sunshine or Sunlight.*—The effect of the sun cognizable as light undoubtedly is a most important consideration in climate in relation to the organic world, but as an item of the state of the atmosphere sunlight is not appreciable. What impress it may make or leave upon the air is yet to be ascertained. As a climatic element, it is measured by its photographic effects. Observation has shown that the photographic effects are stronger in summer than in winter, and in the forenoon than in the afternoon. This is probably the result of the greater freedom of the air from clouds and dust in the morning hours, and to the lessened atmospheric depth traversed by the light rays in the summer.

*Rain.*—Like sunlight, rain makes no continuous impress on the atmosphere. It cannot be regarded strictly as an element, yet it performs an important function in the purification of the air. According to the researches of Aitkin and others, the formation of rain begins by condensation on the dust particles of the atmosphere; in falling to the earth, rain washes down many more; this is why the air is always clearer after precipitation. Rain also brings in solution some of the constituent gases of the air. An important one, and one that exists in such small quantities as to be characterized in amount by the chemist's "trace," is ammonia. But small as is the ammonia content of the air, it is indispensable in the vegetable economy. The relation of rainfall to the humidity of the air is almost that of effect and cause; without sufficient humidity, rain cannot occur. The time of rainfall varies with the cause of its precipitation. Within the tropics, rain falls most often in the afternoons and in the form of heavy downpours. Shortly after the precipitation ends the clouds break up and disappear, leaving the nights cloudless. In the extratropical regions, when the rain comes as one of the consequences of a thunder storm, it is most frequent in the afternoons. In the rains of cyclonic storms, the precipitation may, and does, occur at all hours of the day. The clouds do not break up, as a rule, till some time after the rain has ended, except in the case of thunder storms, after which the clearing is generally more rapid.

The seasonal distribution of rainfall is a most important climatic consideration in connection with vegetation and habitability. Many regions having comparatively large amounts of rainfall in the year are yet unsuitable for vegetation, because the precipitation either does not fall during the spring or summer seasons, or falls all in one or two torrential downpours instead of being distributed in smaller quantities over the growing season. On the other hand, regions that have but a comparatively small yearly rainfall are yet fertile because the precipitation occurs during and throughout the growing seasons.

The present knowledge of the causation of rain may be summarized as follows: To produce abundant rain the temperature of the air must be suddenly brought below that of the dew-point. Air cooled below its dew-point condenses its moisture into minute cloud or fog particles. These particles may float away or be re-evaporated should some cause raise their temperature; or, if in sufficient number and in such motion as to bring them into collision, they may coalesce and form larger and larger drops till they attain sufficient weight to overcome the atmospheric resistance and fall to the ground as rain, snow, or hail, according to the temperature and conditions of condensation. This cooling of the air may be effected, so far as present knowledge goes, by the air being forced up the side of a mountain, as happens when a mountain runs transversely to the direction of the wind; the surface air may become, under the effects of intense insolation of a region, warmed to a degree that will cause it to expand rapidly and thus give rise to ascensional currents, which carry the moisture upward till its dew-point is reached, with resulting condensation and precipitation; and lastly, but most important, at least outside the tropics, by the circulation of the air in cyclonic storms in which there is a surface inflow radially from all sides and a central ascensional movement.

The following broad rules are convenient as indicating the general distribution of rain: Rain is more abundant in warm than in cold countries, that is, its quantity decreases from the equator toward the poles. Rain is more abundant in coast regions than in the inland countries; provided that there be no mountains, or the mountains be far in the interior. Rain is more abundant in hilly and mountainous districts than in lowland regions. Rain is more abundant on windward shores and exposures than on leeward shores and exposures. Rain is more abundant in summer than in winter. It increases in amount up to 5,000 feet above sea level; above this altitude it begins to decrease. Rain in falling washes down many of the impurities, especially dust particles, floating in the air. Regions that have frequent rains have clear and clean atmospheres. The humidity of the air is always greater for some time after a rain because of increased surface evaporation.

Comparative Climatology.—Having sketched what climate is, and how it is primarily dependent upon solar radiation, modified by the agencies called in this connection climatic factors, we should next consider how we may best obtain a knowledge of the difference between the actual climates of the different regions of the earth's surface. The practice of classifying climates is an attempt at the solution of this difficult problem, for difficult problem it is, and will be so found by any one giving careful thought to the subject. Climates are classified variously. There is no definitely settled system; the deciding

| Classification basis. | Subdivisions under classification. | General characteristics of each subdivision. |
|---|---|---|
| Solar or astronomical. | Tropical... | Usually mild, equable, moist, warm, average temperature 80° F. Rainfall frequent and heavy over water and over windward land exposures. Nights usually clear, afternoons cloudy. No general storms. Seasons, rainy and dry; but this division is only a relative one. |
| | Temperate | Unsettled weather, great and variable changes in temperature, rainfall, and moisture from season to season and day to day. Region of cyclonic storms, cold and hot waves, floods and droughts. |
| | Arctic..... | Cold; temperature on average considerably below freezing. Scanty rainfall. Very short but hot summer. Winter long and severe. Storms infrequent. |
| Geographical... | Continental | High temperature in daytime, low at night. Difference between day and night temperatures increases toward center of continent. Great variations in temperature, sometimes hot, sometimes cold. Moisture variable from almost saturation to aridity. Rainfall subject to great variations and extremes. General tendency to extremes in all climatic elements. |
| | Oceanic.... | Temperature equable, range between day and night hardly exceeds 2° to 4° F. in mid-ocean. Moisture high but constant. Rainfall frequent. |
| | Insular and littoral... | Intermediate between above, partaking more or less of the characteristics of one or the other. |
| Topographical (land). | Plain..... | Extremes of temperature great, rainfall uncertain, humidity low. |
| | Hill..... | Extremes of temperature less than plain, rainfall greater, humidity higher. |
| | Mountain... | Generally same as hill, except effects of altitude become more evident; rainfall increases up to about five thousand feet, then decreases. |
| | Valley..... | Extremes of temperature greater than hill. Humidity greater; rainfall greater than plain. |
| | Desert..... | Rainless; great extremes of temperature between night and day and season and season. |
| | Artificial... | Such as climates of large cities. Temperature of cities always higher than surrounding country; haze and cloud and fog more frequent. |
| Aerophysical... | Temperature..... | High, Intermediate, Low — according to the degree of heat adopted as the standard of comparison. |
| | Humidity.. | Damp or moist, Intermediate, Dry or arid — according to standard of humidity adopted. |
| Physiological... | Invigorating ... . Relaxing... Rigorous, etc..... | According to the general effects of the particular climate. |
| | Mild..... Pleasant... Humid..... Disagreeable, etc... | According to the general sensation produced, etc. |

influence being that of the purposes the system is intended to subserve or illustrate. They may be classified with reference to their relative insolation, as solar or astronomical climates; or with reference to the general characteristics impressed on them by the two grand divisions of the earth, as land and water, or continental and marine, climates; or with reference to the possession in greater or lesser degree of some particular physical property, as heat, moisture, etc.; and finally, with regard to their physiological effects, as relaxing, invigorating, rigorous, severe, etc. The foregoing schema will show in a measure some of the possibilities of climatic classification and will suggest combinations that may perhaps be found more applicable to the particular purpose the reader may have in view.

Exact physical measurements of the climatic elements and the effects of the climatic factors are essential to the scientific understanding and utilization of climate. How these elements and factors shall be measured and recorded is a question of the first moment, and one of the most difficult to formulate a satisfactory answer for. What would be a satisfactory determination of climate to the pure meteorologist would probably be unsatisfactory in a greater or lesser degree to the student of climate in its application to other subjects. The botanist, the zoologist, the physiologist, the sociologist, etc., each and all have a different view of climate, and each would measure it in terms not altogether applicable or best suited to the purposes of the others. To measure and record climate in a manner such that each inquirer would find what he looked for and in the shape in which it was wanted, would obviously be a task of magnitude. But, great as would be the undertaking, should any one desire to attempt it, a greater difficulty would be encountered in deciding what was suited to each interest. The discussion of this aspect of the question cannot be opened in this article. For the present, climate is for the most part measured and recorded as the student of meteorology conceives it serviceable and appropriate to the purposes of his science. Taking the climatic statistics as they are generally recorded, the question, however, becomes pertinent how to present them to the best possible advantage for the purposes of general information. Ordinarily these statistics are given in terms of their average values for a period of years. In some respects this kind of climatic information is useful and even indispensable; but it by no means conveys an adequate conception of the weather conditions that may prevail in the regions the statistics represent.

The method of averages, as is well known, smooths out, or masks, irregularities and extremes. The climate of a region is more important in respect to the extreme limits within which the values of its elements fluctuate than in the mean between these limits. The average temperature of two places may be the same, and yet, so far as the distribution of their temperatures either throughout the year or through shorter periods is concerned, they may differ to such an extent as to be unrecognizable when viewed in the light of the total effects of their respective temperatures. As concrete illustrations of this fact there may be cited the mean temperatures of two places in the United States each having, during a period of ten years, the same yearly average of 49° F., viz., Des Moines, Iowa, and Tatoosh Island, Washington. The average temperature of the warmest month at Des Moines was 75° F., at Tatoosh Island 56° F.; the averages of the coldest months were 18° F., and 41° F., respectively. The temperature at Des Moines was observed as high as 104° F., at Tatoosh never above 78° F. At Des Moines, the lowest recorded temperature was 30° F. below zero; at Tatoosh, 7° F. above zero. The total range of temperature observed, that is, the difference between the highest and lowest

temperatures, was 134° F. at Des Moines, and but 85° F. at Tatoosh. Averages may thus be very misleading. Although the mean yearly temperatures of England and of New York are the same, Indian corn will not mature in the former, but does ripen readily in the latter, and all because the summer of England is cool and that of New York warm.

The following table compiled for the city of Washington, D. C., from the records of forty-two years, 1871-1912, shows what in the writer's opinion is a very concise method of presenting meteorological statistics for conveying a fair idea of the climate of a place: what kind of weather is ordinarily to be expected, and what kind of weather may occur:

Of course for special purposes, special arrangements of statistics and special computations are required, but the above table has the advantage that it can be taken almost without additional calculation from the ordinary meteorological records of a first-order station or observatory. Uniformity in the publication of climatic statistics, as in all other kinds, is much to be desired. But such a table as the above does not give all that is desired for a complete conception of the climate of a place. The average and extreme values for seasons and for shorter periods is required. The average diurnal hourly values for each month are important items. The number of days with temperatures below and above certain definite degrees, the number of

WASHINGTON, D. C., RECORD OF FORTY-TWO YEARS, 1871–1912.

| | Jan. | Feb. | March | April | May | June | July | August | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (Fahr.)— | | | | | | | | | | | | |
| Mean or normal | 33 | 34 | 42 | 53 | 64 | 73 | 77 | 74 | 68 | 57 | 45 | 36 |
| Normal maximum | 41 | 43 | 51 | 63 | 74 | 82 | 86 | 84 | 78 | 66 | 54 | 44 |
| Normal minimum | 26 | 26 | 34 | 43 | 54 | 63 | 68 | 66 | 59 | 47 | 37 | 28 |
| Normal variability | 6 | 6 | 6 | 5 | 5 | 4 | 3 | 3 | 4 | 5 | 5 | 5 |
| Warmest month— | | | | | | | | | | | | |
| Year | 1890 | 1890 | 1910 | 1878 | 1880 | 1874 | 1872 | 1900 | 1881 | 1881 | 1902 | 1889 |
| Degrees | 44 | 43 | 51 | 58 | 70 | 78 | 81 | 80 | 77 | 63 | 51 | 46 |
| Coldest month— | | | | | | | | | | | | |
| Year | 1893 | 1895 | 1885 | 1874 | 1907 | 1907 | 1891 | 1903 | 1871 | 1876 | 1880 | 1876 |
| Degrees | 25 | 26 | 34 | 48 | 59 | 66 | 72 | 72 | 62 | 51 | 40 | 26 |
| Highest | | | | | | | | | | | | |
| Degrees | 76 | 78 | 93 | 93 | 96 | 102 | 103 | 101 | 104 | 92 | 80 | 73 |
| Day | 7 | 23 | 23 | 18 | 19 | 9 | 18 | 11 | 7 | 1 | 13 | 6 |
| Year | 1907 | 1874 | 1907 | 1896 | 1911 | 1874 | 1887 | 1900 | 1881 | 1881 | 1879 | 1912 |
| Lowest | | | | | | | | | | | | |
| Degrees | −14 | −15 | 4 | 22 | 33 | 43 | 52 | 49 | 36 | 26 | 12 | −13 |
| Day | 1 | 11 | 4 | 19 | 11 | 2 | 4 | 24 | 23 | 31 | 22 | 31 |
| Year | 1881 | 1899 | 1873 | 1875 | 1906 | 1897 | 1907 | 1890 | 1904 | 1893 | 1880 | 1880 |
| Frost— | | | | | | | | | | | | |
| Average date first killing frost (in autumn)— | | | | | | | | | | | | |
| Day | | | | | | | | | | 22 | | |
| Average date last killing frost (in spring)— | | | | | | | | | | | | |
| Day | | | | 10 | | | | | | | | |
| Humidity— | | | | | | | | | | | | |
| Normal relative | 72% | 69% | 69% | 62% | 70% | 74% | 73% | 77% | 79% | 76% | 72% | 71% |
| Normal absolute, in inches per cu. ft. | 1.6 | 1.6 | 2.1 | 2.8 | 4.6 | 6.5 | 7.3 | 7.0 | 5.9 | 3.9 | 2.5 | 1.7 |
| Precipitation in inches— | | | | | | | | | | | | |
| Average monthly | 3.37 | 3.42 | 3.85 | 3.25 | 3.83 | 4.18 | 4.65 | 4.40 | 3.59 | 3.09 | 2.71 | 3.16 |
| Average number of days 0.01 inch or more. | 12 | 11 | 12 | 11 | 12 | 11 | 11 | 11 | 8 | 8 | 9 | 10 |
| Greatest monthly— | | | | | | | | | | | | |
| Year | 1882 | 1884 | 1891 | 1889 | 1889 | 1900 | 1886 | 1906 | 1876 | 1885 | 1877 | 1901 |
| Amount | 7.09 | 6.84 | 8.84 | 9.13 | 10.69 | 10.94 | 10.63 | 14.36 | 10.81 | 8.69 | 7.18 | 7.56 |
| Least monthly— | | | | | | | | | | | | |
| Year | 1872 | 1901 | 1910 | 1871 | 1911 | 1894 | 1872 | 1895 | 1884 | 1874 | 1908 | 1889 |
| Amount | 0.35 | 0.62 | 0.57 | 0.91 | 0.87 | 1.24 | 0.82 | 0.82 | 0.14 | 0.29 | 0.60 | 0.19 |
| Greatest amount in twenty-four hours— | | | | | | | | | | | | |
| Amount | 2.28 | 2.29 | 2.80 | 3.21 | 3.50 | 4.16 | 5.80 | 4.96 | 5.66 | 3.98 | 2.83 | 2.70 |
| Day | 4 | 5 6 | 3-4 | 25 26 | 7-8 | 22 | 29-30 | 12 | 15-16 | 4 | 24 | 17 |
| Year | 1886 | 1896 | 1909 | 1889 | 1886 | 1886 | 1878 | 1898 | 1874 | 1877 | 1877 | 1888 |
| Greatest amount snowfall in twenty-four hours— | | | | | | | | | | | | |
| Amount (inches) | 9 | 12 | 10 | 4 | Trace | | | | | Trace | 4 | 10 |
| Day | 6 | 13 | 4 | 6 | 10 | | | | | 5 | 4 | 26 |
| Year | 1892 | 1899 | 1909 | 1889 | 1906 | | | | | 1892 | 1910 | 1890 |
| Weather— | | | | | | | | | | | | |
| Average number of days— | | | | | | | | | | | | |
| Clear | 8 | 9 | 9 | 11 | 11 | 11 | 11 | 11 | 12 | 14 | 11 | 11 |
| Partly cloudy | 10 | 9 | 11 | 10 | 11 | 12 | 13 | 12 | 10 | 8 | 9 | 9 |
| Cloudy | 13 | 10 | 11 | 9 | 9 | 7 | 7 | 8 | 8 | 9 | 10 | 11 |
| Wind— | | | | | | | | | | | | |
| Prevailing | N. W. | N. W. | N. W. | N. W. | S. | S. | S. | S. | S. | N. W. | N. W. | N. W. |
| Normal velocity in miles per hour. | 7 | 8 | 8 | 8 | 6 | 6 | 5 | 5 | 5 | 6 | 7 | 7 |
| Highest velocity— | | | | | | | | | | | | |
| Miles per hour | 46 | 60 | 48 | 43 | 54 | 51 | 60 | 53 | 66 | 51 | 54 | 49 |
| From | N. W. | N. W. | N. W. | N. W. | S. W. | N. W. | N. W. | N. | S. E. | N. W. | S. W. | W. |
| Day | 30 | 2 | 15 | 2 | 28 | 16 | 28 | 5 | 29 | 4 | 23 | 9 |
| Year | 1894 | 1876 | 1911 | 1912 | 1896 | 1912 | 1877 | 1878 | 1896 | 1877 | 1891 | 1876 |

hours of bright sunshine, etc., are also matters of importance. In fact, the fullest conception of a climate can be had only by going into great detail and by looking at the values of the climatic elements in a variety of ways. In the study of individual climates, those of small areas can be pursued by the statistical method, of which the above table is an illustration. But for the study of general climates this method is too laborious, and the less accurate but easier method of graphic representation is used. In some respects graphic methods are more impressive and more readily grasped, and for this reason are much employed wherever the matter lends itself to such treatment. The preceding charts (Plate XXVII.) showing the distribution of temperature over the surface of the earth in the months of January and July, are illustrations of graphic or chartographic methods. These charts show at a glance the effects of some of the disturbing and modifying influences concerned in bringing about the very complex distribution of climate on the earth's surface. The elevation of the January isotherms on the northwest coasts of America and Europe is strikingly evident. This is due to the westerly winds and ocean currents of these latitudes. The depression of the July isotherms in the same regions is due to the same causes. In the winter the waters of the North Pacific and the North Atlantic are warmer than the land, in the summer they are cooler; hence the winds blowing from them to the land carry the climatic conditions of the oceans to a greater or less extent inland.

Artificial Climate.—Under this caption attention is called in passing to the effect of dwellings and other types of buildings upon the physical state of the atmosphere in them, and to the fact that this is a subject deserving consideration, especially from the sanitary and hygienic point of view. So pronounced and permanent is this effect that it constitutes a climatic condition of its own kind, and one deserving of the name given it—artificial climate.

To go into consideration of the characteristics of this kind of climate would exceed the prescribed limits of the present article. However, it is worth while to state that houses have climates as peculiar to themselves as are the climates of oceans, continents, mountains, and plains.

Applied Climatology.—The relation of climate to the organic world is one of the most interesting and at the same time intricate of the problems that present themselves for scientific investigation. The relation of climate to the distribution of organic life has been discussed from time out of mind, but beyond a few generalizations little has been yet found out. That climate does control absolutely in some way the forms of life scattered with more or less appearance of regularity over the earth is a proposition that is generally admitted. It is the foundation stone of the modern theory of evolution. Indeed, it would be most difficult for any one to refute successfully the claims put forward in support of climatic control. However, it must be admitted that it is impossible at present to express the geographic distribution of the organic world in terms of functions of climate. Whether it will ever be possible to predicate with scientific precision the peculiarities of form, habits, and health that will be the necessary outcome of a given climate cannot be asserted at present either positively or negatively.

*Climate and Man.*—If the presence of man only be considered, it will be found that he exists in all known climates, from the equator to the poles, from the hottest to the coldest, in the driest and in the dampest, and in equable and in variable climates. So far as ability to live is concerned, man appears, at first sight, to be independent of his climatic environment. Yet such is actually not the case. By intelligent foresight man is enabled to combat more or less successfully effects that would otherwise overcome him. Virtually he makes for himself an artificial climate. Deprived of the means of surrounding his person with this artificial climate, he would be restricted to very narrow geographic ranges. By the addition of clothing, he conserves his body temperature when his atmospheric surroundings would dissipate it too rapidly. He reenforces when necessary the protection of his habiliments by refuge in dwellings and by aid of artificial heat, both of which his ingenuity has devised. On the other hand, when his climatic surroundings, or the weather, go to the opposite extreme he constructs fans and punkahs to create artificial breezes, and he brings ice that has been stored from the previous winter, or made by his refrigerating machines, to cool himself. If the region produce not the food that he requires, he transports it from where it can be obtained, and he varies the quality of that of his own locality by importation from abroad. Should the resources at his command prove insufficient for health and happiness he migrates to climates more to his liking. The human body has, however, a great natural tolerance for both heat and cold. Jacobabad, in India, is a city of 5,000 inhabitants, and its average July temperature is 96° F., but two degrees less than that of the human body. The United States Weather Bureau maintained from May to October, 1891, a station in Death Valley, Cal., and the observer, Mr. J. H. Clery, spent July and August in that place with mean monthly temperatures of 102° F. and 101° F. respectively. The inhabitants of Verkhoiansk, in Northern Siberia, endure a midwinter temperature of 60° F. below zero, or 92° below freezing. In ordinary winters of the temperate zones, quite frequently man passes suddenly from a warm room at 75° or 80° to the outdoors with maybe its temperature of zero or below. He lives in the deserts of Arabia and Africa, where clouds are seldom seen and rain more than once or twice a year is an unusual occurrence; and he flourishes in the tropical islands where rain and cloud are daily phenomena, and in the Khasia hills with their nearly 500 inches of rain a year.

Different races are endowed with different degrees of climatic resistance. The Eskimos, living in the cold and cheerless north, wrapped in skins, and huddled in ice dens as houses, find life outside of the Arctic circle almost unendurable. The Latin races of Europe live readily in the tropics where the Teutonic stock must struggle incessantly for existence. The Chinese may be found living easily from Manchuria to Australia. The Jew lives everywhere. He is as much at home in the climates of Siberia as in his native Palestine, and he is found from Cairo to the Cape. The Ethiopian can live in the hot jungles of the torrid zone, but finds it hard to flourish in the temperate climates of the northern United States. All this shows that it is not so much the climate as it is the man and the race. It is the personal equation of living after all, the habits and modes of life, that account for this varied tolerance. Climate places its imprint upon social life and customs, and long usage makes it hard to abandon them, even when reason and experience show their evil effects. The average Caucasian carries with him to the tropics the same habits of life, food, and drink, and even clothing, that he has acquired in the colder north, and then wonders at his inability to become acclimated in the torrid zone. He forgets that the winter frosts of his northern home atoned for many of his sanitary sins that in the tropics bring often fatal retribution upon him. In the deserts and on the great treeless plains where water and grass often fail, man becomes a nomad, driving his herds and flocks from place to place in search of sustenance. In the forest regions he fells trees and builds a cabin or a kraal, and lays the foundation of a permanent home. The character of the climate affects the habitation he erects for his use.

Under the hot sun of the tropics his house is low and open, the shade is sought and every breeze courted. Farther northward the house grows higher and the openings are fewer and fewer. From wood and open construction it passes to brick and stone, and compact structure; and every device that promises to keep the outside climate out and the inside climate in is sought for. Still farther north, because it is hard to heat a large building in the intense cold of the Arctics, the house becomes smaller, and from the modern skyscraper, with its furnaces, fans, and electric lights, and its other numerous conveniences, it descends to the small dugout, and the ice-cabin, wherein human beings huddle together for warmth from each other's bodies, the only sufficient source of heat at their command.

Climate leaves its impress even upon fiction and history, upon poetry and prose, religion and superstitions. To the wandering Bedouin, he who dug a well was a benefactor; paradoxically the well was the monument of a philanthropist. To die of thirst with water vanishing ere it touches the parched lips is the Arab's direst curse, and green trees and running waters his ideal of paradise. In the colder north, where the sufferings from cold and want of heat are felt, demons in red, with heated forks and fiery furnaces, terrorized the wicked and restrained the good, and the halls of Valhalla were the hope of a hereafter. Upon the features climate perhaps has an influence, but the periods required for many changes are relatively so great that we cannot measure them. Within historic times there is no evidence of ethnic change. The Ethiopian of to-day is the Ethiopian upon the basreliefs of Nineveh and Babylon. And the modern Egyptian fellah wandering about the streets of Cairo was depicted in the reign of the Pharaohs.

From the influence of climate on man's modes and life, it follows that directly or indirectly climate must exert a profound influence upon his physical well-being. Abundant evidence of this influence is seen in the geographical distribution of certain diseases and their behavior when transported by commerce and migrations to other regions. Cholera and yellow fever are endemic within the sea-level altitudes of the tropics. Both occasionally are carried by agencies beyond their indigenous climates, and both after a longer or shorter time disappear completely from their new homes. The former lives longer out of its native habitat than the latter, which vanishes with the first air temperature of 32° or lower. Malaria is a widespread disease extending geographically on each side of the equator to the limits of the isotherm of 60°; beyond this it is not endemic. Malaria and yellow fever are carried by certain species of mosquito, *Anopheles* and *Stegomyia calopus*, respectively. *Anopheles* has a larger climatic life zone, and its larvæ withstands the frosts of the average winter of the temperate zone. *Stegomyia calopus* and its larvæ are killed by the first heavy frost. Some forms of disease, as diphtheria, pneumonia, phthisis, rheumatism, nephritis, and others, show no definite climatic limits, and may apparently exist in any locality. Sunstroke, frost-bite, snow-blindness, and mountain sickness are perhaps the only ones that can be said to be caused by the climatic conditions under which they develop. The most important influence of climate is that which it sustains as a predisposing agent. The manner in which this influence may be exerted will depend upon the nature of the disease.

Modern research warrants the classification of disease into two general categories, viz., infectious and non-infectious; the germ diseases and the non-germ diseases. Of the first class, obviously those diseases that result from the presence of the strictly obligate parasites can be affected solely through the medium of the host; and so we find the diseases from such germs everywhere that the diseased host may migrate and live. Among this class are rabies, syphilis, and gonorrhea. Upon the exciting causes of these diseases climate has no opportunity to act directly. Upon obligate parasites, but those of greater resistance, and which may exist for some time outside of the animal body, but which probably do not lead a saprophytic existence, there is opportunity for climatic effect. To this class belong the germs of diphtheria, glanders, variola, measles, and scarlatina. And there is some reason for supposing that the variations in virulence manifested in the different epidemics of these diseases are partly due to such causes. Upon the facultative saprophytes and the facultative parasites there is abundant opportunity for the effects of meteorological agencies. Under one or the other of these classes are the germs of phthisis, anthrax, typhoid, cholera, tetanus, malaria, yellow fever, and the various pyogenetic microbes. And, again, the evidence of variation in malignancy of these diseases can be accounted for, at present at least, only on the supposition of some favorable or unfavorable meteorological influences. Further corroboration of the probability of such suppositions is furnished in the experiments that have been made by different observers on the attenuation of microbic virulence when the microorganisms were grown under certain physical conditions of temperature, humidity, and illumination. The effect upon the different pathogenic microorganisms is particularly noticeable in respect to sunlight. Moist bacilli and spores of anthrax are killed by two hours' direct exposure to the sunlight. A few minutes in the sunlight will kill tubercle bacilli, diffuse sunlight will kill them in from six to seven days, and they gradually lose their virulence in from two and a half to three months in ordinarily lighted dwelling houses. Two hours' insolation is sufficient to kill typhoid bacilli. A few hours' drying will kill the comma bacillus of cholera. None of the pathogenetic parasites multiply under temperatures below 50° F.

Experiments have shown that physical environment can profoundly alter the resistance of the host to infection. Hens will not contract anthrax unless they be first chilled by exposure to the cold. Frogs become susceptible to the disease if kept in an atmosphere of 80° F. or more. Bowditch in this country and Buchanan independently, in England, showed that soil dampness favored the development of tuberculosis. The relation of the ground water and its fluctuations to typhoid has been widely discussed, and the maximum prevalence of the disease after the hot weather of summer has suggested a lowered resistance in the human body. The general prevalence of pneumonia in winter, and its relatively great frequency in climates of high altitudes, have pointed to a meteorological predisposition. As has been mentioned previously, the absolute atmospheric humidity is controlled by the temperature. A cubic foot of air at 32° F. can contain at the most but 2.1 grains of moisture; at 98° F. it can contain 18.7 grains. A cubic foot of air inspired at 32° F. or below, is warmed up in the respiratory passages to about 98°, and is expired saturated with moisture, and it takes from these passages 16.6 grains of water. If this moisture be not supplied rapidly enough by the nasobronchial mucous membrane, dryness and mechanical irritation result, and this may be the sufficient predisposition for the graver disease, the preparation of the soil for the germ. Excessive evaporation from the respiratory passages is a fact both in cold weather and in elevated regions, and pneumonias are then and there prevalent. Longstaff found that diarrheal diseases became epidemic in London when the water of the Thames reached 62° F., and Ballard, looking in another direction, found them epidemic when the temperature of the ground four feet below the surface rose for the season to 56° F. The foregoing facts suggest that the application of a knowledge of climatic conditions and climatology can be of great service to hygiene, both personal and general.

The treatment of disease by climate forms an inter-

esting and important chapter in medical literature. The particular manner and the properties of climate that effect the cures are still subjects of medical polemics. The chief disease that climate is relied upon for curing, to the exclusion of almost all else, is phthisis. Within the past ten years much attention has been paid to and gratifying progress made in what is known as the sanatorium treatment of tuberculosis. Because of the success that has followed this method, many writers are disposed to belittle climate as a therapeutic agent in this disease. However, unbiased analysis will show that, after all, sanatorium treatment is climatic treatment—nothing more than using the home climate intelligently. With so many, climate is something one has to go far away from home to get. That change of climate in this disease is beneficial would be folly to attempt to gainsay. The present consensus of medical opinion leans to the climates of altitude, particularly those above three thousand feet elevation. Altitude, moderate temperatures, clear skies, and well-drained soil appear to be the climatic desiderata for this disease. In this malady the physiological effects of high altitude have usually been considered as the most efficient therapeutic properties of the climate.

The present writer, from a careful consideration of the known physiological actions of the different climatic elements and factors, takes exception to the claims of altitude in this disease. Without entering into any discussion he ventures to state that whatever virtue there is in such widely recognized climates as Colorado, the Engadine Alps, and others as sanitaria for phthisis, flows from the absence of clouds and is due to the effects of the intense insolation under low atmospheric temperatures that favor life passed in the direct sunlight rather than in the shade.

The utilization and indications for climate in diseases belong rather to the therapeutics of each disease than to the present article, which is but a brief attempt to define climate and point out the general principles that will indicate what climates are to be expected in given localities, or, a particular kind of climate being desired, where it can be most nearly approximated. In climatotherapy, however, one should bear in mind, as a motto, the dictum of Scoresby-Jackson: "If it be a good thing for a sick man to change his residence, it must be a proper thing for him to know what it is that he is avoiding, and what it is that he is to acquire in exchange for it in another place." The what-it-is-that-is-to-be-avoided and the what-acquired must be worked out by the physiologist, pathologist, and the therapeutist much more thoroughly than at present before climatotherapy can becomeo ther than empiricism.

*Climate and Animals.*—Endued with only a limited degree of reasoning ability, but few animals evince any intelligent foresight in providing against future contingencies of heat, cold, famine, or drought. The nearest approach to prevision is exhibited in the migratory and the hibernating habits of some animals, and in the storage of food by a few others. The climatic control of the distribution of animals is perhaps as much one of indirection as of direction. Cats cannot live at an elevation of 11,000 feet, and all efforts to introduce the Newfoundland dog in India have failed. The polar bear cannot live outside of the isotherm of 32° F., unless surrounded with an artificial reproduction of its native climate. On the other hand, many natives of the tropics find no difficulty in living in the colder temperate zones. Parrots introduced into England flourish in the woods of Norfolk, and that they have not spread over the island is more a matter of food supply than of inimical climatic conditions. The tiger stands the jungle climates of Bengal and the snows of Thibet with equal impunity. The elephant, found now only in the tropics, once roamed over the tablelands of Siberia. The matter of food supply and the ease with which food can be obtained are more influential than the direct physiological effects of the climate itself.

Adaptation to climatic conditions is seen in many animals. The change of color and of thickness of the pelage with the change of seasons is a physiological tribute to climate. The peculiar body formation of many animals is an accommodation to the direct influence of climate. The arboreal animals are unfitted for the treeless prairie. The camel is found in the desert, but it would perish in the forest. Sheep and goats are adapted to the climate of mountains, but not to that of forests. In each and every case we shall find an effort at accommodation in one way or another to climatic environment, and in most of the cases the adaptation is one rather to the food supply, and ultimately to the vegetation of the climate, than to the immediate physiological effects of the meteorological environment.

The key to climatic control of the distribution of animals is in the struggle for food. Many of the extinct animals disappeared not from any secular change of climate, but simply from the advent, often perhaps accidental, of some other form that preyed upon it or its food supply. Goats introduced into the island of St. Helena destroyed a whole flora of trees, and with it doubtless disappeared many if not all of the parasites dependent upon it. Swine introduced in Mauritius destroyed the dodo. The mongoose in Jamaica has completely exterminated the native fauna of that island.

*Climate and Vegetation.*—The character and distribution of vegetation are both distinctively climatic results. Light, heat, and moisture, in greater or lesser degrees, are essential to the development of vegetable life. The measures in which these elements are combined determine the general characteristic features of the vegetation. Variations of degree in these characteristics result from the combination of the effects of climate and those of other factors, as the structure and composition of the soil, the effects of animal life, etc. The intense heat and generally abundant moisture of the tropics favor a luxuriant growth in forms that in colder regions are diminutive in size. The vegetation of arid regions is distinct from that of humid countries; and the vegetation of the hot deserts is different from that of the deserts of colder latitudes. Under the equator palms and bananas are the typical forms; then, receding toward the poles, come in succession tree ferns and figs, myrtles and laurels, evergreens, deciduous trees, conifers, lichens and dwarf shrubs, and mosses. If we ascend a high tropical mountain we shall find the same change of vegetational formation.

The following tabular view will present the approximate general distribution of vegetational types with reference to the average temperature under which each best develops.

| Zone of— | Average temperature of zone. | Altitude of each under the equator. |
|---|---|---|
| Palms, Bananas | 82°–70° F. | At sea level. |
| Tree ferns, Figs | 78 –73 | From sea level to 2,000 feet. |
| Myrtles, Laurels | 73 –68 | From 2,000 to 4,000 feet. |
| Evergreens | 68 –60 | From 4,000 to 6,000 feet. |
| Deciduous Trees | 60 –48 | From 6,000 to 8,000 feet. |
| Conifers (pines, etc.) | 48 –40 | From 8,000 to 10,000 feet. |
| Lichens | 40 –32 | From 10,000 to 12,000 feet. |
| Mosses | 32° and lower | From 12,000 to 14,000 feet. |

The distribution of the temperature and the rainfall are the most important factors in vegetation. And it is the heat of the summer rather than the cold of

winter that determines the limit of vegetation. A broad generalization has been made to the effect that the geographical distribution of animals is dependent upon that of the minimum temperatures of winter, and the geographical distribution of the different varieties of plants is dependent upon the maximum temperatures of summer. Observation of the lowest temperatures at which most plants begin to germinate shows that vital action is not evident till the temperature rises to 43° F. This is the first effective temperature. Plant growth takes place only so long as the temperature is at or above this point, and the amount of growth that actually takes place, other conditions being favorable, is estimated by the product of the number of hours by the number of degrees the temperature is above 42° F. This product is called the accumulated temperature, and represents the total effective temperature for plant development. The higher the temperature, up to a certain optimum, varying for different plants, the greater the rate of growth. The study of plant growth and meteorology is receiving the scientific attention that it so well merits. When more progress has been made scientific phenology will be a most important and valuable assistance to mankind. W. F. R. Phillips.

**Climatotherapy.**—Although the various health resorts of importance in America and abroad will receive special notice in the Handbook, it is the purpose of this article to consider the effects and value of climate in general in the prevention and treatment of disease.

From time immemorial the beneficial influence of change of climate has been recognized but precise knowledge both of meteorological data and of the effects of the various climatic elements upon the human organism have been and are still, to a greater or lesser extent wanting. Like many other therapeutic measures, the applications of climate in disease have been to a large extent empirical. With some knowledge of meteorology, however, and of the accumulated experience and observations of climate and its effects in various quarters of the globe, a more scientific and intelligent use of this highly valuable means of treating disease can now be made.

In order to do this, two things are necessary: First, a definite knowledge of climate in general with all that this embraces; and, second, the influence of climate upon various diseases and conditions. To differentiate still further, we must know the effects of the various climatic elements in general; their effect upon any individual case under consideration; where or in what resort such climatic elements as we desire for the treatment of the case are to be found; and, finally, if the local conditions are such that the favorable climatic elements can be adequately utilized. As all climates, like drugs, have as well their deleterious as their beneficial side, we must be aware of the former in order to guard against them; for example, we must know that the climate of deserts in warm latitudes is subject to great diurnal variations of temperature, and when the sun goes down the heat is rapidly radiated from the sandy soil and the temperature quickly falls, so that the invalid must avoid or protect himself from this rapid cooling of the atmosphere. Or, again, he must remember that the climate of high altitudes puts an unusual strain upon the heart on account of the rarification of the atmosphere, and hence the altitudes are dangerous for those with weak or diseased hearts.

There are a large number of diseases, especially of a chronic nature, and of weakened conditions of the body from age, previous acute illnesses, or inheritance which can be favorably influenced by a change of climate; and when restoration to health cannot be obtained, at least life can be prolonged and made more comfortable. This is especially true of diseases of the respiratory passages for which a change of climate is perhaps more frequently advised than for any other condition.

An accurate knowledge of one's home climate is of no small value not only for the sake of comparison in the investigation of other climates but as well for the sake of avoiding, so far as may be, climatic influences which for special conditions or diseases are injurious. For example, wind, and a moist, chilly atmosphere, are unfavorable conditions for renal disease; or, again, moist air combined with cold predisposes to catarrhs, bronchitis, and rheumatism. Furthermore, by taking advantage of all the favorable influences of one's home climate, not infrequently quite as beneficial effects may be obtained, or even better, than by the indifferent utilization of a more favorable climate.

Sanatoria for pulmonary tuberculosis situated in ordinary temperate climates, like those of our northern States, by utilizing to the full such favorable climatic conditions as exist, show excellent results, better perhaps than those obtained in open resorts with more advantageous climatic conditions but less rigorously applied.

Before going further in the discussion of climatotherapy, it will be well to state exactly what we mean by climate. Climate as defined by Hermann Weber is "the combined results of the influences exercised by air, soil, or water on organic life in any given locality." The temperature of the air, its humidity, motion, density, electrification, and precipitation constitute *climatic elements.* "The conditions that cause variations in the intensity of the climatic elements constitute the climatic factors; the principal ones of which are latitude, altitude, distribution of and and water, mountain ranges, ocean currents, prevailing winds, amount and distribution of rainfall, nature of the soil and its drainage and vegetation, and the slope of its surface" (Phillips).

The terms "climate" and "weather" are often used synonymously, but by the term weather we mean those atmospheric elements which we see, feel, or observe by instruments at a particular time or specified period; while by climate we mean the aggregate of weather conditions; and the average value of these conditions of any region constitute its climate. For example, the winter climate of northern and middle New England is cold and there is considerable snow, but the weather of last winter may have been comparatively mild with little snow.

Practically, in judging of the climate of any place, we want to know, first, what is the average daily temperature, either for the year or for the season in which one vists the health resort. For instance, if it is a resort in Florida, we want to know the average winter temperature; if Mt. Desert, the average summer one. Next, the average daily range from which we obtain an idea of the equability of the temperature. Then the mean of the warmest and coldest days, which is the average daily maximum and minimum temperature of all the days of any month throughout the entire period of observation. Again, the absolute maximum and minimum temperature reached on any day of the given month in any year of the period of observation. "These extremes of temperature," as Dr. Huntington Richards remarks, "are the chances the invalid has got to take in any resort; they do not indicate what temperature he may expect, but what it may be his good or evil fortune to encounter."

Again, the humidity is an important factor to determine, especially the relative humidity, as also the average rainfall for the various seasons.

The prevailing direction of the wind and its velocity are again obviously important facts.

Finally, using the term weather arbitrarily, we include under it the average number of clear, fair, cloudy, and rainy days.

The two great fundamental prerequisites of any climate used in the treatment of disease are pure aseptic air, and an abundance of light and sunshine. Location must determine the one—a place unsurrounded by contaminating influences, like thickly inhabited centers; and latitude to a greater or lesser extent, the other. It is obvious, however, that not all regions which possess both of these qualifications are suitable for health resorts. Other climatic elements and conditions must be taken into account, but these two must exist in all climatic resorts. Sunshine is not only a mental stimulant but has a tonic effect upon the whole organism. Sunshine is inimical to bacteria, notably the tubercle bacillus. Rollier at Leysin in Switzerland has shown the remarkable benefits of sunshine upon the naked body in cases of bone, joint, and gland diseases in children. Outdoor life is what is desired in any resort and without a large number of clear and fair days this is seriously interfered with. A cool, dry, pure air and sunshine, such as is met with in many of the high-altitude resorts, make a combination of striking value for many cases of tuberculosis.

As to temperature, the degree of heat or cold, that must depend upon the disease condition for which a change of climate is desired, and also upon the other climatic elements. For some conditions warmth is desirable, as, for example, for persons of low vitality, such as the aged or very young; for others, as in most cases of pulmonary tuberculosis in a curable stage, a moderately low temperature is preferable, for it has been found that the "average tuberculous patient makes his best gain in cold dry weather." A high temperature with a low humidity is less uncomfortable than heat with a high humidity. So also is a low temperature.

Wind and altitude have also much to do with the effects of temperature. A cold still atmosphere can be comfortably endured, while with wind the same temperature would be unbearable. So also is a low temperature made comfortable by the greater diathermancy of the attenuated air of altitudes. A large daily range of temperature, which is often the concomitant of a low humidity, may be objectionable for certain diseases, but one can provide against it by remaining indoors before the sun is up and after it sets, and by using heavier wraps when it is overcast.

Moisture, or high humidity, is objectionable for many diseases, particularly pulmonary tuberculosis. With some it may be even of value, as in bronchitis when the expectoration is scanty and the cough hard and dry. Moist air retards evaporation from the skin and lungs. Moist, cold air is not only exceedingly uncomfortable but increases the functional activity of the kidneys and predisposes to catarrhal affections of the respiratory and genito-urinary tracts. When judging of the dryness or moisture of the air, the relative humidity, as has been said above, has generally been taken as a guide, but it must always be considered in connection with the temperature, and in order to make a fair comparison, some standard temperature should be taken. 55° F. is given by Mendt as the mean annual temperature of the United States, and this can be taken as a standard.

Assuming this standard, we can, according to Solly (Medical Climatology, p. 34), make the generalization that 50 per cent. or less relative humidity is dry; 65 to 75 per cent. is medium; 75 to 85 per cent. is moist; and any above, very moist.

It is to be borne in mind that a dry climate is not an equable one, and the lower the relative humidity, the greater the daily range of temperature.

A considerable rainfall is generally an unfavorable condition; but, on the other hand, as Weber says (Allbutt and Rolleston's System of Medicine, 1905, vol. i., p. 294,) rain is to some degree useful as it has a purifying influence upon the atmosphere, provided time enough be left for the invalid to be out of doors.

The character of the soil is also to be considered in connection with the rainfall; if the former is porous, quickly absorbing moisture, the amount of rainfall is of less importance than if the soil is clayey and holds the water.

Winds vary in their effect according to the temperature, humidity, purity, and velocity of the air in motion. High winds are generally, however, undesirable, often producing great and sudden changes. Cold, damp winds are never good, and cold, or hot, dry winds, like the Mistral of the Riviera or the Föhn of Switzerland, are too irritating or debilitating. The direction of the winds is also an important factor in considering their influence upon the invalid, for from one direction they may come fresh and pure, blowing over clear spaces or forest expanses, while from another they may come laden with dust and other impurities, exhausted of their ozone and deficient in oxygen. Snow, which is dry and remains upon the ground a long time without melting, protects the atmosphere from dust and earthy impurities, and hence renders it more sterile.

Besides the purely climatic data there are other facts which it is essential to know with regard to any health resort, such as the configuration of the land, whether mountainous, hilly, or flat; the existence or not of water in the form of river, lake, or pond; the character of the soil and vegetation.

In addition, one should have some knowledge of the water system, drainage, sanitary condition, hotels and boarding houses, and all such factors as would render a resort either more or less favorable for an invalid.

Furthermore, one should also be assured, if possible, of a reliable local physician to whom to refer the patient in case of need.

Finally, in the selection of a suitable climate and resort for any disease or condition for which a change is considered desirable, the writer cannot do better than to repeat for the guidance of the practitioner the three principles enunciated in the first edition of this Handbook by Dr. Huntington Richards:

"1. A thoughtful, conscientious, and painstaking consideration of the precise pathological condition of the individual patient, and of his constitutional peculiarities.

"2. A careful study of the effects produced upon the human organism, both in health and disease, by variations in each and all of the meteorological factors of climates.

"3. The detailed study of these factors as they exist in the climate of each place which experience has proved to be, or analogy has led us to regard as likely to be well suited for use as a health resort."

And to this may be added the wise conclusion of Solly that in selecting a climate for an invalid, let us above all remember to examine not only the suitable application of the climatic factors to the disease, but also the peculiarities of the individual and his attendant circumstances.

Various classifications of climates have been made by different authors depending upon the purpose the system of classification is intended to subserve or illustrate. We have the so-called solar or astronomical classification with the subdivisions of tropical, temperate, and arctic. The geographical, with the divisions of continental, oceanic, insular, and littoral. The topographical, with the divisions of plain, hill, mountain, valley, and desert. The aerophysical of Phillips, depending upon temperature and humidity. Another is upon a physiological basis as (a) tonic or stimulant; (b) sedative or relaxing. Huggard (Handbook of Climatic Treatment) makes an ingenious classification, depending upon the heat demands made by the climate.

Weber's classification appears to be the simplest and sufficiently definite for intelligent description and appreciation. He makes two general divisions:

Marine (including sea and coast climates) and inland climates.

Under the first general division we have the purely marine climate, as illustrated by the ocean, and small islands lying out in the ocean, and coast resorts whose climate is more or less marine.

MARINE, or ocean climates are characterized by equability, purity of atmosphere, humidity, and abundance of light. The temperature, of course, depends upon the latitude. Heat, moreover, is less oppressive upon the ocean than upon the land even at the same temperature. Even at the tropics heat on the ocean is seldom oppressive unless there is an absence of wind. The ocean climate is a sedative tonic one; it is sedative to the nervous system and a stimulant to the appetite and digestion. Sea voyages were formerly recommended for persons suffering from pulmonary tuberculosis, particularly by the English physicians, but so much more appropriate climatic conditions and surroundings are found on land, particularly the sanatorium, that they are now rarely employed. Sea voyages are, however, of value in various other conditions, such as overwork, worry, insomnia, mental breakdown, neurasthenia, and irritable weakness of the nervous system, delayed convalescence, various scrofulous conditions, hay fever and asthma. In chronic catarrhal conditions of the larynx and air passages, and in chronic rheumatic conditions, sea voyages to warm climates are said to be frequently useful. Sea voyages are contraindicated to those who suffer from sea-sickness, from melancholia on account of the suicidal tendency, from serious chronic diseases, and from cholelithiasis or chronic disorders of the stomach and intestines; "a febrile tendency," says Huggard, "is a contraindication for a sea voyage." There are innumerable voyages, long and short, available from this country. In the colder portions of the year one can go to Bermuda, the West Indies, Central and South America; to Madeira and the Mediterranean; from San Francisco to Hawaii or other islands in the Pacific. There are also various voyages along the southern Atlantic coast to Savannah, Florida, New Orleans, etc.

In the warmer months of the year to the continent of Europe or the British Islands, and various cruises about Europe such as that to Norway and the North Cape. Shorter voyages can be taken to Nova Scotia and through the Gulf of St. Lawrence and up the river, and to various ports on the Atlantic coast, and through the Great Lakes. Small islands in the midst of the ocean, or sufficiently distant from the land to be free of its influence have an almost purely marine climate. Such are Bermuda, the Bahamas, Porto Rico, Block Island, the Isles of Shoals, etc. The conditions mentioned as being benefited by sea voyages are also favorably influenced by residences on such islands.

"*Coast climates*, like ocean climates, are characterized by purity of air, and by greater humidity, and equability than inland climates." They are, however, modified by the land influence. Here we have the land as well as the sea breezes, causing less equability and less constant purity of air. A coast climate is also influenced by the configuration and character of the adjacent land. For example, the Alps influence the climate of the Riviera, giving rise to the cold winds which sweep down upon the coast; the desert influences the character of the climate upon the African coast; the inland desert the littoral of Australia. The Undercliff at Ventnor, by its shelter from land influences, is rendered a more purely marine climate.

Seaside health resorts from a therapeutic point of view, may be divided into a warm group for winter use and a colder group for summer residence. Of the former we have such places as Bermuda, the West Indies, Florida, the coast of Mississippi, Atlantic City, frequented both summer and winter, Old Point Comfort, and various others on the south Atlantic and Gulf Coast. In Europe various resorts on the Mediterranean coast. Of the colder group we have such resorts as all of those on our north Atlantic coast, illustrated by Mt. Desert, the Maine, New Hampshire, and Massachusetts coasts, and the somewhat warmer resorts of New Jersey, Long Island and those on the northwestern coast of Europe.

Sea air, as found at the seaside resorts, is beneficial in debilitated and anemic patients; in scrofulous and weakly children; in insomnia and mental exhaustion, and in a variety of conditions depending upon a deterioration of the general health. Sea bathing often increases the favorable influence of the sea air, but it should be prescribed in each individual case by the physician. The more bracing climates are suitable for those of stronger constitution; while the milder climates are to be chosen for those of lessened powers of reaction.

Weber also divides marine climates into *humid marine* and marine with *moderate* or *slight humidity*.

Of the humid marine warm climates, Madeira, the Canaries, the West Indies, the coast of Florida are examples. Such climates exercise a sedative effect upon the nervous system and mucous membranes, and are useful in chronic bronchitis with emphysema, bronchial catarrh, and pulmonary congestion in elderly people without cardiac complications. Of the warm marine climates with moderate or slight humidity, we have the Riviera, the coast resorts of southern California, southeastern Georgia, and Solly also includes Florida under this head. The effect and uses of such climates are practically the same as those of the previous class. All the sea-coast resorts of the North may be classed under *cool* marine climates with moderate humidity.

Of the INLAND CLIMATES we have first those of low or sea level, which are susceptible of classification according to temperature and humidity. We have the dry warm and the dry cold climates, and those which are more or less moist, although as a rule, all inland climates are drier than coast climates. Of the dry warm climates we have those of the deserts and arid plains, such as are met with in Egypt, the low plains of Arizona and New Mexico, the inland resorts of southern California, such as Riverside and Redlands, the dry pine belt of the Southern States, and others in various parts of the world. According to H. Weber, the characteristics of desert climates are purity of the air, richness in ozone, great warmth of the sun, abundant light, dryness of the air, and great scarcity of rain. Violent winds and the consequent dust are the greatest disadvantages of such climates. The dust irritates the eyes and the nasal mucous membranes, gets into the clothing and houses. A dry warm low-level climate is suitable for many cases of pulmonary tuberculosis, chronic bronchitis, rheumatism, cardiac and renal diseases, convalescence from pneumonia, and bronchitis, functional nervous disorders, feebleness from old age or other causes, etc.

The dry and cold climates of low levels have not been extensively utilized in the treatment of disease, although they would appear to offer certain favorable conditions for pulmonary tuberculosis in patients of good constitution and resisting power. Various sanatoria in this country and Europe are situated in cold climates of little or no altitude, or, at least, in climates with cold winters.

The difference between medium and high altitudes is obviously largely one of degree; medium altitudes possess characteristics of both low-level climates and those of altitude; moreover, not alone does the elevation influence the character of the climate, but the latitude, the proximity to the ocean and to mountain ranges, and the configuration of the surrounding country; thus Estes Park in Colorado is comparable

with Davos in Switzerland, although the former is 1,000 or more feet higher than the latter. The general climatic characteristics of the mountain health resorts are: a rarefied atmosphere, aseptic air, increased diathermancy, dryness, abundant sunshine, and a comparatively low temperature. The purity of the air of high altitudes has been compared to that of the ocean and of the desert.

It has previously been supposed and asserted that the lessened barometric pressure of altitudes was an element of great value, perhaps the greatest in mountain climates in their influence upon pulmonary tuberculosis, but of late this has been doubted, and one is more inclined to believe that the essential value of the climates of altitudes in the treatment of pulmonary tuberculosis resides in the greater purity of the air, the absence of clouds, the intense insolation under low atmospheric temperatures that favor life passed in the direct sunlight rather than in the shade, and the general stimulating effect upon metabolism of such a climate, so far as his personal experience goes, the writer believes that, considering the element of climate alone, the high altitudes, as illustrated by the resorts of Colorado, for example, produce the best results in tuberculosis when it is in a stage to be amenable to climate at all.

The majority of the sanatoria for tuberculosis are situated in medium altitudes, although there are not a few in the higher regions, as at Davos, Leysin, and other places in Switzerland, and in Denver and Colorado Springs and others in this country. The climate of medium altitudes generally has a greater humidity, less intense insolation, the air is generally warmer, and there is more mist. It is less stimulating and tonic than that of the higher altitudes. It is better suited for patients with a tendency to dilatation of the heart and with degenerative changes in the vascular system, with emphysema, or renal disease, and of an irritable nervous constitution; also for those of advanced age.

The effect of altitude upon tuberculosis is not altogether dependent upon the exact number of feet any resort is above the sealevel, but, as has been stated above, also upon its latitude and distance from the ocean. Hence there are many places of medium altitude which offer many of the valuable factors of an elevated climate with the exception of the greater rarity of the air.

High-altitude climates are found in all the four quarters of the globe: the Alps in Europe; the Andes in South America; the Himalayas in Asia; the Rocky Mountains in North America; the lofty plateaux of Mexico; and the high altitudes of Australia and South Africa. Davos, St. Moritz, Arosa, and Leysin are examples of high-altitude health resorts in Europe; while Les Avants, Gœrbersdorf, St. Blasien, and many others in the Black Forest, Harz Mountains, and Alpine foothills are illustrations of mountain resorts of moderate elevation.

The elevated resorts of the Rocky Mountains, from 5,000 to 7,000 feet, have a dryer climate and more sunshine than those of Europe. The principal resorts are found in Colorado, New Mexico, Arizona, Utah, and Texas. Many which are climatically valuable are unavailable on account of the absence of suitable accommodations.

In Colorado we have Colorado Springs, Denver, Estes Park, Glenwood Springs, and others; in New Mexico, Santa Fé, Albuquerque, Las Cruces (3,800 feet) and Silver City; in Arizona, Prescott, Phœnix (1,100 feet), and Tucson (2,400); in Utah, Salt Lake City; in Texas, El Paso. There are also many resorts of lesser elevation in the Adirondacks, Alleghenies, Appalachian and White Mountains, such as Saranac, Asheville, Bethlehem, Kane, and Mount Pocono. In Mexico we have the City of Mexico, Guadalajara, Agu as Calientes, Toluca,all over 5,000 feet high, and many others. In South America we have the region upon the Pacific slopes of the Andes, many years ago made known as favorable for phthisis by Dr. Archibald Smith. The elevation varies from 8,000 to 12,000 feet, and the chief climatic characteristics are: (1) Moderate warmth; (2) equability of temperature; (3) abundant sunshine; and (4) moderate dryness. There may be mentioned Jauja, Bogota, Quito, Arequipa, and Huancayo.

"Unfortunately," says Weber, "at none of the resorts is the accommodation good enough for invalids."

In India, Darjiling (8,200 feet), Simla, Landour, Naini Tal, and Murree are some of the best spoken-of stations. According to Weber, the testimony of Indian medical officers appears to be rather against the use of the Himalayas in the treatment of lung diseases "and apparently this is on account of the heavy rainfall." In South Africa, Kimberley, Bloomfontein, and Pretoria, all 4,000 feet high or over, are some of the places used as health resorts. "The accommodations for invalids," remarks Williams, "are not up to the European standard," but the climate, he says, has yielded excellent results in his hands.

In Australia, there is the highland region embracing the slopes of the Australian Alps, with an elevation of from 2,000 to 7,000 feet, but only Mount Macedon in Victoria (2,500 feet) and Mount Victoria, New South Wales (3,490 feet) offer satisfactory accommodations to invalids.

Special Indications.—Regarding the adaptability of certain climates to the treatment of special diseases, only a few general indications will be given here, and the reader is referred to the articles upon the various health resorts in the Handbook for a more detailed considera'ion of this portion of the subject.

For *pulmonary tuberculosis*, for which a health resort is sought more frequently than for any other disease, the essential climatic conditions are pure air free from dust, protection from high winds, moderate dryness and equability, and a dry soil. Such a combination of conditions is not hard to find nor does one have to travel far to obtain it. With it, however, must be associated, as has so often been insisted upon, the most careful, continuous, medical supervision; hence the great value of sanatoria.

It must also ever be borne in mind that the stage of the disease, its activity, and the general condition of the patient are always to be carefully considered in deciding upon a resort, or if any change is advisable.

Assuming that the patient is in the incipient, curable stage, and that there are no other contraindicating conditions, the writer would arrange the favorable climates in the following order of excellence: (*a*) High altitudes, like Colorado, New Mexico, the Alps; (*b*) low altitudes, like the Adirondacks, Asheville, the Southern pine belt, and southern California; (*c*) coast climates, represented by the Riviera resorts; (*d*) island climates, like Madeira and the Canaries; (*e*) ocean voyages. As to results, according to Solly ("Medical Climatology," p. 141), the high altitudes are the best, the sanatoria the next, and the lowland climates come third.

*Bronchitis.*—When expectoration is abundant, a dry, warm, inland climate like Thomasville, Augusta, Summerville, and Camden, S. C., southern California, in the winter; and the seaside or mountains in the summer. If the expectoration is scanty, a warm moist climate like Florida, Nassau, Algiers, Madeira, in winter; and Newport, the Jersey coast, Nantucket, Cape Cod, etc., in the summer.

*Pleurisy.*—In the convalescent stage when recovery is delayed, or the lung does not expand, the higher altitudes, provided the condition of the heart permits. Likewise in retarded pneumonia, in individuals under thirty-five years of age, and when the heart is normal, and the lungs are not too seriously involved, Solly recommends the higher altitudes, under proper restrictions.

*Asthma (Bronchial).*—Although the climatic treatment of this complex disease is largely a matter of trial, yet the high-altitude resorts appear to give the best results, especially when the neurotic element seems to be the prominent factor in the case. If the bronchitis, the determining cause, seems to be the most important element, either a sedative or a stimulant climate is to be selected according to the character of the bronchitis. Or if the exciting cause appears to be the most important, especial consideration must be given to that in the selection of a resort. In general one may mention among others such resorts as Colorado, the White Mountains, Arizona, and Lake Placid as favorable for many cases.

*Hay Fever (Nasal Asthma).*—The Adirondacks, White, Catskill, and Allegheny Mountains, Mackinac Island, Georgian Bay, Cape Breton, the "North Woods," Beach Haven, Fire Island, and Halifax, Nova Scotia, are some of the many resorts which afford more or less immunity. An ocean voyage and travelling in Europe are also prophylactic.

*Tuberculous Glands and Tuberculosis of the Bones and Joints.*—Seaside resorts, sea voyages, and high altitudes. The seaside preferably, with salt baths.

*Rheumatism.*—Warmth, dryness, equability, and sunshine are essential factors in the climatic treatment of rheumatism; such conditions are found in Texas, Arizona, the Southern Pine Belt, some portions of southern California, the inland Florida resorts, the desert of Egypt, and Algeria.

It is also to be remembered that the hydrotherapeutic treatment of this disease as exhibited at such resorts as Richfield Springs, the Virginia Hot Springs, the Arkansas Hot Springs, Aix-les-Bains, and others, is most efficacious.

*Gout.*—Much the same climate as for rheumatism, in general dry inland resorts.

*Renal Disease.*—A warm, equable, windless climate, such as is found in many low inland or coast resorts, examples of which are Arizona, Madeira, the Southern Pine Belt, Florida, southern California, etc. The West Indies are highly extolled by Burney Yeo.

*Diabetes Mellitus.*—Warm interior or coast climates such as the coast of Florida, Southern California, Atlantic City, Old Point Comfort, Va., Aiken, S. C., Thomasville, Ga.

*Cardiac Affections.*—Warmth, equability, sunshine, and in some cases moderate elevation. "With regard to the heart and great vessels," says Solly ("Hare's System of Practical Therapeutics"), "it may be stated as a generality that they are much more apt to be improved on the sea than on the mountains." The coast resorts are favorable for this class of affections.

*Chronic Diseases of the Genito-urinary Organs.*—Warm and moderately dry climates. Renal tuberculosis requires in general the same climate as pulmonary tuberculosis.

*Nervous Maladies.*—Each disease must receive its own especial consideration in regard to climate. Some, perhaps the most, require a mild, low climate; others a mildly stimulating one.

*Neurasthenia.*—Any climate which affords rest, a change of scene and diet, with life in the open air, such as a life in the woods, at sea, or on the plains, is likely to be beneficial. Solly is of the opinion that the larger proportion of cases of neurasthenia are most surely and quickly benefited by high climates, when no especial contraindications exist. When any one symptom is predominant, a climate which is favorable to that is to be selected. If it is insomnia, for instance, the climate which best relieves that—sometimes high altitudes, sometimes the low resorts or the seashore—will prove most beneficial to the general condition.

*Senility with its Accompanying Changes.*—A warm, sunny, equable climate, where the individual can exist comfortably with the least expenditure of vital force; in winter Florida, southern California, the Riviera, many resorts in the Southern States. In summer, the New Jersey, Long Island, and Southern New England coasts—the White Mts., Rangeley Lakes, Poland Springs, Lake George and Lake Champlain, Saratoga Springs, and many others. Whatever the resort selected it is of the first importance that good accommodations and food should be assured.

*Convalescence from acute diseases*, such as typhoid fever, epidemic influenza, whooping-cough, diphtheria, etc. A warm, sunny climate, inland or seashore, where the patient can live out of doors, protected from wind, and can bathe in the sunshine. Atlantic City, Old Point Comfort, Lakewood, are examples.

*Anemia.*—Tonic inland or coast climates such as the White and Adirondack Mts., Colorado, New England and Long Island coast in summer, and various springs, such as Hot Springs, Va., Sharon and Richfield, N. Y.

A word in conclusion regarding home climates. It is true with climates as with other things, that familiarity often breeds contempt. In looking for a health resort we too often forget the possibilities of our own home climate. In the treatment of pulmonary tuberculosis, as well as other diseases we can, not infrequently, obtain surprising results by a painstaking utilization of the favorable climatic conditions existing in the patient's own locality.

A judicious arrangement of rooms and verandas so as to obtain the utmost possible sunshine and out-of-door life, ingenuity in providing shelter from the wind, ample ventilation, and an equal attention to the hygienic-dietetic *régime* which we would give in a health resort, with the same assiduous devotion to getting well, may produce as happy results as those obtained in many well-known health resorts.

Therefore the physician or his patient should not give up hope by any manner of means, if the conditions preclude a change of climate. "I can cure consumption in any climate," said Dettweiler.

EDWARD O. OTIS.

**Climax Springs.**—Camden County, Missouri.

POST-OFFICE.—Climax. Hotel.

ACCESS.—From St. Louis via Missouri Pacific Railroad to Sedalia and Warsaw, Missouri. From Warsaw by carriage 25 miles to the springs. Also 30 miles by carriage from Versailles and Eldon, on the Missouri Pacific, and 38 miles from Lebanon on the St. Louis and San Francisco Railroad.

The following analysis was made by H. W. Wiley:

ONE WINE GALLON CONTAINS:

| Solids. | Grains. |
|---|---|
| Magnesium iodide and bromide | 10.00 |
| Calcium sulphate | 5.66 |
| Calcium carbonate | 5.22 |
| Potassium iodide and bromide | 2.55 |
| Sodium chloride | 35.61 |
| Iron, aluminum, and silicon oxide | 8.00 |
| Organic and not determined bodies | 3.39 |
| Total solids. | 70.43 |

| Gas. | Cubic inches. |
|---|---|
| Carbonic acid | 27.60 |

The waters are remarkable for the quantity of iodine and bromine which they contain. They are somewhat similar to the waters of the celebrated Kreutznach Springs, of Prussia, but are far stronger in these ingredients. Such waters are especially adapted for the treatment of chronic syphilitic and scrofulous affections, rheumatism, dyspepsia, diseases of the liver, kidneys, and glands; epilepsy, dropsy, and the various diseases of women.

EMMA E. WALKER.

**Clonarchis.**—A genus of flukes, containing two species, *C. sinensis* and *C. endemicus*, found as parasites in the liver and gall-bladder of man. Infection is probably from eating poorly cooked fish. See *Trematoda*. A. S. P.

**Clonus.**—In general clonus refers to a rhythmical series of muscular contractions, and is usually confined in its application to those produced by a sudden passive stretching of a tendon. Clonic muscular contractions are those contractions, due to the alternate activity of agonist and antagonist muscles and are characteristic features of the epileptic convulsion. This latter group of muscular activities is not here dealt with under the head of clonus. Clonus is a correllate of an increased tendon reflex, and any tendon reflex, when much increased, may develop a clonus of the muscle in question if a proper kind of passive tension can be maintained. This is practicable only for a few of the muscles of the body. Thus in clinical medicine only a comparatively few varieties of clonus are available. These are ankle clonus, patellar or knee clonus, toe clonus, jaw clonus, elbow clonus, wrist clonus, and finger clonus.

The most accurately studied of these is ankle clonus. This is due to a hyperexcitability of the Achilles tendon reflex and may be developed in two or three positions. Historically speaking the older method of Charcot and Vulpian (1862) consisted in slightly flexing the extended leg at the knee, the patient being either lying down or seated; then with one hand lightly supporting the leg just below the popliteal space and up to the calf, insuring as much limpness as possible in this slightly flexed position, the foot is grasped just above the middle and a sudden plantar flexion is made; the hand then holds the foot in this position placing the Achilles tendon on the stretch. In true ankle clonus, "trepidation," there is a rhythmical series of up and down movements of the foot which may continue for a considerable series of fluctuations depending upon the condition of the reflex. This method is that most frequently utilized and is the one which has been used in practically all of the studies made upon ankle clonus, particularly those of Levi (Obersteiners Arbeiten, vol. xvi., *Neur. Centralblatt*, 1909, p. 414, *L'Encéphale*, 1908, p. 260), Claude (*Rev. Neur.*, 1906, p. 829), James (*Scot. Med. and Surg. Jl.*, 1900) and Sarbo (Berlin, 1903, a monograph), where more complete details may be sought concerning this important reflex disturbance.

Ankle clonus may also be obtained by having the patient in a sitting position. He should then rest his toes upon the floor, raise the heels, putting the Achilles tendon in tension and then quickly pushing the knees down when an up-and-down motion takes place. This type of clonus occurs at times spontaneously in healthy reflex arcs. A third method is that of the Babinski method for obtaining the Achilles reflex. Here the patient kneels upon a chair the feet just hanging over the edge, the Achilles tendon is struck when rhythmical contractions take place which soon cease however.

By the first or more classical method it is very important that the leg should be held as limp as possible, hence a slight support as indicated is desirable. This supporting hand or half arm can thus determine if tension is removed, otherwise it may be impossible to elicit the clonus. In certain very spastic cases the removal of hypertonicity is impossible; many of these patients fail to reveal clonus because of this marked hypertonicity of the entire leg.

In others again it becomes difficult to determine if one is dealing with a true or a false clonus. A half dozen or more rhythmical contractions occur and then rapidly die down. This pseudoclonus may or may not be an index of increased Achilles reflex spinal excitability. Thus it is by no means infrequent in certain hysterical states. Here however a study of Levi's curves would point to the fact that the pseudoclonus of hysteria, while still possibly indicating a reflex arc of excitability (psychical component), yet the contractions are usually more rapid than those seen where there is a lesion of the first motor neuron, *i.e.* pyramidal tract system. The clonus or trepidation obtained in the second method spoken of is not due either to any increased reflex activity as seen in hysteria, nor yet is it due properly to a pyramidal disturbance. It seems to be a protection reflex which would extricate the foot from an embarrassing position, as it most frequently occurs when the foot is cramped in a certain position resting on the toes. The trepidation demands a change of position and first brings it about automatically when later conscious activities further the relieving automatic movements by a complete change of position.

In certain other non-neurological conditions one may encounter a pseudoclonus or even a clonus of such pronounced though not lasting character that one is misled into the notion that a cord lesion is present. Articular rheumatism, and joint tuberculosis are among such. A more definite clonus appears in scopolamine narcosis and often in ether or chloroform narcosis. Lewandowsky (Handbuch der Neurologie) cites the presence of clonus in mercurial poisoning.

Certain patients show inequalities in ankle clonus on opposite sides. This inequality, even in very mild forms of ankle clonus, perhaps even suggestive of pseudoclonus, is highly suggestive of an organic interruption of the pyramidal pathways. Again continuous clonus, even during sleep, has been charted by Levi. In other types of a marked clonus the rhythmical contractions will continue even if the tendon is not kept on stretch by the hand being held against the foot.

As stated, the significance of ankle clonus is that of an increased Achilles reflex. It indicates a lesion in the first motor neuron somewhere in its course from the cortical motor cells to their termination at the synaptic junction in the lumbar cord with the motor cells of the gastrocnemius and soleus groups. By itself ankle clonus affords no clue as to the localization of the lesion, either cortical, capsular, peduncular, midbrain, medullary, or spinal; nor does it give any clue as to the nature of the lesion, whether hemorrhage, tumor, multiple sclerosis, arteriosclerosis, Pott's disease, syphilis, or what not. Its presence only indicates a functional cutting off of certain pathways which travel in the pyramidal tract system.

Patellar clonus consists in the rhythmical contraction of the adductor groups when the patellar is suddenly pushed downward toward the toes, the leg lying in an extended position. It has the significance of an exaggerated patellar reflex. (See *Reflexes*.)

Wrist clonus may be elicited in certain severe pyramidal tract lesions, capsular hemorrhage, multiple sclerosis (Bouchard 1866) by a sudden flexion of the hand on the wrist the tension being maintained on the extensor tendons as in the case of the foot. It is an exaggeration of the extensor wrist reflex.

In total section of the cord the deep reflexes may be lost entirely notwithstanding the fact that there is a pyramidal tract lesion. The later appearance of a clonus following such a disturbance, as may result from fracture of the spine, bullet or stab wound of spine, etc., is evidence of incomplete severance of the cord. Smith Ely Jelliffe.

**Clover, Joseph.**—Born in Norwich, England, February 28, 1825, Clover was educated at University College Medical School and Hospital, London. He was in residence in the hospital with Lister in 1846 when Liston performed there the first operation under ether, and thus early in his medical career became interested in the subject of surgical anesthesia. When

in 1864, the Royal Medical and Chirurgical Society appointed a committee to investigate the subject of anesthetics, being impelled thereto by the many accidents occurring under cholorform administration, Clover was the adviser of the committee and did much to promote the claims of ether as a safer anesthetic than chloroform. He invented the ether inhalers which bear his name, and also a bag inhaler for chloroform, and was an advocate of the combined method of giving nitrous oxide gas with ether.

As a surgeon also Clover won no little renown. He did much to facilitate the operation of lithotrity, being the inventor of the double-current evacuating tube and rubber bottle which made possible the crushing of the stone and removal of the fragments in one session. He was never a strong man physically, his studies and early medical career being repeatedly interrupted by illness, and the end came to him at the comparatively early age of fifty-seven years, his death occurring on September 27, 1882. T. L. S.

**Clover, Red.**—The flower heads of *Trifolium pratense* L. (fam. *Leguminosæ*). The herbage of most of the two or three hundred species of *Trifolium* is rich in albuminous nutriment, or *legumin*, and red clover is one of the best and the most extensively cultivated of these fodders. During recent years it has come into prominence as an ingredient of a "shot-gun" preparation, used as an alterative, of which the other ingredients represent the activity.

HENRY H. RUSBY.

**Clover, Sweet.**—See *Melilot.*

**Cloverdale Lithia Springs.**—Cumberland County, Pennsylvania.

POST-OFFICE.—Newville.

ACCESS.—Both Cloverdale Lithia Springs and Doubling Gap White Sulphur Springs are reached by stage over a good macadamized State road. During the summer automobiles run to Doubling Gap Springs. Doubling Gap is a fine summer resort with a large hotel.

Cloverdale Springs, an artesian mineral-water fountain, is located two and a half miles northwest of Newville and five miles south of the Doubling Gap White Sulphur Springs. It was discovered in 1865 by a party prospecting for oil. The opening bored through the solid rock to a great depth struck this water vein, which, being released from its subterranean confinement, gushed to the surface at the rate of 300 gallons per hour under the pressure of its own carbonic acid gas. The flow since that time has never diminished, being uniform at all seasons of the year. The water is perfectly clear and entirely free of organic matter, and has a temperature at the spring of 52° F. The following analysis was made by Prof. E. T. Fristoe, of the Columbian University, Washington, D. C.

ONE UNITED STATES GALLON CONTAINS:

| Solids. | Grains. |
|---|---|
| Potassium carbonate | 0.20 |
| Lithium carbonate | 0.17 |
| Magnesium sulphate | 1.60 |
| Magnesium chloride | 0.09 |
| Sodium chloride | Trace. |
| Magnesium bicarbonate | 0.42 |
| Calcium bicarbonate | 6.67 |
| Iron oxide and alumina | 0.75 |
| Silica | 0.80 |
| Phosphoric acid | Trace. |
| Total | 10 70 |

| Gases. | Cubic inches. |
|---|---|
| Carbonic acid | 1.070 |
| Oxygen | 1.109 |
| Nitrogen | 6.013 |

This water is not heavily impregnated with mineral ingredients, yet when taken in sufficient quantities it exerts an undoubted influence on the physical economy. It has been found to possess antacid, mild aperient, and tonic effects. Its clear and sparkling appearance and freedom from organic impurities qualify it for table and domestic purposes. The water is used commercially. EMMA E. WALKER.

**Cloves.**—See *Caryophyllus.*

**Clubbed Fingers; Clubbed Hand.**—See *Hand and Fingers, Diseases and Deformities of.*

**Club-Foot.**—See *Foot, Distortion of.*

**Clysmic Water.**—See *Waukesha.*

**Coagulation.**—Most of the animal proteins can be obtained in solution. Many of these may be coagulated or rendered insoluble by different means. As to the nature of the process, we know very little in addition to the fact that there is a striking physical difference between the substance formed and the material from which it was produced. The degree of insolubility varies with the different proteins and the means by which coagulation is produced. There is a distinct difference between precipitation and coagulation of proteins. In the former the precipitate may be redissolved again in suitable media, while in the latter the coagulum cannot be dissolved by ordinary media. The difference is well illustrated by the action of alcohol upon proteins. Albumins and globulins are at first precipitated by this reagent—the precipitate may be redissolved; after standing under alcohol for days or weeks they are coagulated and cannot be redissolved. Alcohol also precipitates proteoses and peptones, but does not coagulate them. Ammonium sulphate in saturation will precipitate all proteins except peptones, but does not coagulate any of them.

COAGULATION BY HEAT AND BY CHEMICAL REAGENTS.—The coagulation of egg white by boiling is the most familiar example of heat coagulation. The temperature necessary to produce coagulation varies with different proteins. Thus fibrinogen and myosin coagulate at 56° C.; egg albumin and muscle albumin at 73° C.; serum globulin at 75° C. Serum albumin, which was once regarded as a single body, has been found by Halliburton to consist of three different bodies having coagulation points at 73°, 77°, and 84° C. respectively. Not only does the coagulation point vary with different proteins, but even for the same protein it varies with the salts present and the reaction of the solution. Coagulation occurs much more readily and completely in an acid than in an alkaline or neutral medium.

From the readiness with which albumins and globulins are coagulated by heat they are often called the coagulable proteins. Vegetable albumins and globulins are coagulated by heat like those of animal origin. Some non-coagulable protiens may be coagulated under certain conditions—*e.g.* acid and alkali albumins are non-coagulable when in solution, but after precipitation by neutralization they can be coagulated by heat. Proteins coagulated by heat cannot be dissolved by water or saline solution of any strength. Weak acids or alkalies dissolve them only with the aid of heat. The digestive ferments however, readily act upon them in suitable media.

We know no chemical difference between the coagulum formed by heat and that formed by chemical reagents, but the proteins formed by the coagulating ferments can still be coagulated by heat. Thus myosin of muscle can be extracted by saline solution, but not after it has been boiled. In the digestion of

fresh fibrin intermediate products occur which cannot be obtained when it has been boiled. The proteins coagulated by ferments are much more soluble in strong solutions of neutral salts and in weak acids or alkalies than are those coagulated by heat or chemical reagents.

Coagulated proteins behave like native proteins to those tests which can be applied, such as the color tests.

The chemical reagents causing coagulation without definite compounds (such as are formed by salts of the heavy metals) are alcohol, picric acid, tannic acid, and strong mineral acids. Fixation agents such as alcohol, formalin, osmic acid, and mercuric chloride cause coagulation of the proteins of protoplasm in preserving tissues and cause a reticular formation in the cell formerly described as spongioplasm.

Coagulation of Blood.—When blood is shed it soon becomes viscid, and in from three to ten minutes sets in a jelly-like clot or coagulum. The coagulum shrinks and gradually the clear yellowish blood serum separates from the clot. The clot consists of a fibrillar substance, fibrin, entangling the corpuscles in its meshes. Although the clot forms a bulky mass from the large number of corpuscles contained in it, the actual amount of dried fibrin that can be obtained from blood is small, being only from 0.2 to 0.4 per cent. by weight. The corupscles are not at all necessary for the formation of the clot, as they can be removed in various ways, and coagulation occurs in the fluid of the blood—the plasma—as perfectly as when they are present. The essential part of the clot is the fibrin, a coagulated protein which is formed when blood or lymph coagulates. The whole problem of coagulation of the blood centers in the formation of fibrin, and the factors which go to form it.

Fibrin is formed from fibrinogen, a globulin which is normally in solution in blood plasma and has certain peculiarities which distinguish it from other globulins. Fibrinogen is acted upon in some way by thrombin or fibrin ferment and is converted into fibrin. The fibrinogen is completely used up in the formation of fibrin so that none remains in solution in blood serum. The thrombin or fibrin ferment can be obtained from blood serum by adding a large excess of alcohol and extracting the precipitate with water after sufficient time has elapsed for the coagulation of the proteins by the alcohol.

It is impossible to state what change occurs when thrombin unites with fibrinogen. Until quite recently it was generally accepted that the action of thrombin is that of a ferment as its older name, fibrin ferment, indicates. Recent investigations have shown that it has certain properties which are different from other enzymes. Thus, it has been found that it can withstand boiling under certain conditions; also that the quantity of fibrin formed is proportionate to the amount of thrombin added to the fibrinogen, without reference to the time allowed for the action between the two. It has recently been suggested that the interaction between the thrombin and fibrinogen is a combination of a physicochemical nature which results in the precipitation of the gelatinous and insoluble fibrin. Although fibrin is insoluble in water, thrombin can be extracted from it by solutions of sodium chloride.

Thrombin does not exist in the circulating blood but develops very soon after blood is shed or when the blood-vessel is injured. The nature of thrombin, the substances which enter into its formation, and the sources of the same, have received careful study from numerous investigators. As the result of these investigations different theories of coagulation have been advanced from time to time. It is impossible to go into details here and only the facts which seem to be definitely established will be stated briefly.

Three substances appear to be necessary for the formation of thrombin: (1) a lime salt; (2) thrombogen or prothrombin, and (3) a thromboplastic substance generally called thrombokinase. The lime salt and the thrombogen are in solution in the plasma of the circulating blood at all times. The thrombokinase occurs in the blood only after it is shed or comes in contact with tissues outside of the endothelium lining the vascular system.

In all probability it results from the explosive disintegration of blood platelets which occurs with amazing rapidity when blood is shed. It is true a thromboplastic substance can be extracted from the leucocytes and from the stroma of erythrocytes. But these cells do not disintegrate to an appreciable extent within the first few minutes after blood is shed and it is doubtful if they contribute to the formation of thrombokinase ordinarily.

Thrombokinase may also be extracted in considerable amount from the various tissues. In birds it seems to be derived chiefly from the tissues, as the blood-platelets are absent from their blood. This accounts for the delayed coagulation in the blood of the lower vertebrates when the blood is received into a glass tube directly from a blood-vessel without coming in contact with the injured blood-vessel or tissues. The thromboplastic substance (thrombokinase) can be extracted from the tissues by ether and alcohol. It is most abundant in tissues rich in nucleins. In ordinary watery extracts it appears to be in combination with a protein which is precipitated by heating.

All three of the substances going to form thrombin seem to be necessary for coagulation. When any one of them is absent purified fibrinogen cannot be converted into fibrin from the action of the other two.

*Why the Blood does not Coagulate within the Blood-vessels.*—This may be explained by the fact that active thrombin does not exist in the circulating blood on account of the absence of thrombokinase. This explanation would seem to be in harmony with the theory of coagulation given above concerning the factors which are necessary for the formation of fibrin. It is not a complete and satisfactory explanation, however, as blood serum containing thrombin, or solutions of active thrombin, may be injected in considerable amount without causing intravascular clotting. Extracts of tissues containing a thromboplastic substance or thrombokinase may also be injected into the circulation without producing thrombosis, as the clotting within the blood-vessels is called. In fact, extracts of tissues rich in nucleins and thrombokinase (*e.g.* thymus, lymph glands, etc.) may lessen the coagulability temporarily—the so-called negative phase of coagulation—when injected slowly and in small quantities. When injected rapidly or in large quantities, the coagulability is increased and extensive thrombosis may result. This is remarkable since tissue extracts only influence intravascular clotting and seem to be without effect upon the coagulation of shed blood.

These facts would seem to indicate that the animal body can in some way dispose of thrombin in moderate amounts or develop antibodies which neutralize thrombin or thrombokinase in a physiological sense, thus preventing intravascular clotting within certain limits. It seems highly probable that the body develops an antithrombin or an antikinase to prevent intravascular clotting just as the digestive organs develop antipepsin and antitrypsin in giving the immunity which they have against autodigestion. That antithrombin exists in the blood may be demonstrated experimentally.

Hirudin, which is obtained from the heads of leeches, prevents extravascular clotting when mixed with shed blood and also destroys the coagulability of the blood when injected into an animal intravenously. It may be considered as an antithrombin as it prevents active thrombin from acting upon fibrinogen,

probably by uniting with thrombin to form an inert body.

Commercial peptone does not have any effect upon extravascular clotting but when injected into the living animal causes the blood to lose its property of clotting. When the liver is removed from an animal it fails to have this effect; after peptone solution has been perfused through the liver for a time it contains an antithrombin.

After peptone has been injected into an animal in sufficient amount, the plasma not only fails to coagulate itself, but it prevents thrombin from acting upon fibrinogen when added to such a mixture. If the peptonized plasma is first heated to 80° C. and filtered, the filtrate no longer restrains the action of thrombin upon fibrinogen. Evidently the antithrombin, which appears to be produced in the liver under the influence of commercial peptone, and which is destroyed by heat, is similar to hirudin in its action.

The fluidity of the blood may normally depend upon the presence of antithrombin in the blood. It is evidently present in at least sufficient amount to neutralize the thrombin that results from the disintegration of blood-platelets and leucocytes which occurs normally. It also explains the failure to produce thrombosis when thrombin or thrombokinase is injected in moderate amounts and not too rapidly. The formation of a thrombus which occurs when a blood-vessel is injured or a foreign body is introduced, is probably due to the agglutination and rapid solution of blood-platelets. This results in the liberation of a large amount of thrombokinase which cannot be neutralized in that locality as the circulation is usually interrupted.

Howell has advanced the view that active thrombin may be formed from the interaction of thrombogen or prothrombin, which is normally present in the blood plasma, with a lime salt; that the thromboplastic substance resulting from the disintegration of platelets and normally contained in various tissues of the body, acts by neutralizing the antithrombin which normally prevents coagulation, and that this thromboplastic substance is not a kinase or activating agent as is generally accepted in the theory of coagulation given above.

The coagulability of the blood is a matter of practical interest, as this is nature's means of preventing death from hemorrhage. There is considerable variation in the coagulability of the blood of different individuals and probably in different conditions of health. In disease the variation is even greater. In acute infections the coagulability may be increased. This is particularly true in pneumonia and diphtheria. These diseases are accompanied by the greatest leucocytosis and leucolysis. It is probable that the condition can be explained by the extensive disintegration of a large number of cells within the blood and the liberation of their constituents. Possibly there is also a change in the platelets similar to that in the leucocytes.

The coagulability of the blood is increased greatly during starvation and it increases rapidly during severe hemorrhage. In neither of these conditions is there any leucocytosis. It may be that there is an increase in the formation of thrombin or a temporary decrease in the production of antithrombin.

On the other hand the coagulability of the blood may be greatly diminished and the amount of antithrombin may possibly determine this. In the curious disease, hemophilia, the coagulability of the blood is almost entirely lost. According to Wright this condition is due to a deficiency of lime salts and may be relieved by restoring the normal amount of lime salts in the blood, either by local application or by the internal administration of these salts. Clinicians have recently found considerable benefit from the injection of normal blood serum in hemophilic conditions. Doubtless this is due to the development of a thrombin. This appears to be more promising than the administration of lime salts alone.

The coagulation of shed blood may be hastened by contact with foreign surfaces. Whipping or agitation of blood removes the fibrin in a few minutes as this favors the disintegration of the blood-platelets and causes the fibrin to adhere to the foreign surface. Heat also hastens coagulation as it favors the formation of thrombin and its action upon fibrinogen. Sponging with very hot solutions stops hemorrhage from a bleeding surface in this way aside from its effect upon the blood-vessels of the part.

The following conditions retard coagulation: (1) Receiving blood directly from the blood-vessel into a vessel coated with paraffin so that it cannot be wetted by the blood. (2) Receiving the blood in small tubes surrounded by a freezing mixture. The cold prevents the disintegration of the blood-platelets. (3) Receiving the blood directly into a solution of a soluble oxalate, of such amount that it will form 0.1 per cent. of the total, prevents coagulation by forming an insoluble calcium oxalate. In this way the blood is decalcified before the formation of thrombin can take place. (4) Receiving blood into one-fourth its volume of a saturated solution of magnesium sulphate or sodium sulphate. Salted plasma will clot on the additon of water or a solution of thrombin. The salt in sufficient concentration appears to prevent the disintegration of blood-platelets. (5) Sodium fluoride, in the proportion of 3 parts per 1000, prevents coagulation by forming the insoluble calcium fluoride and also by causing fixation of the cellular elements of the blood, thus preventing their disintegration. (6) Sodium citrate prevents coagulation by forming a double salt with calcium thus removing the free calcium salt from the plasma and preventing the formation of thrombin. (7) Hirudin, obtained from the salivary glands of leeches, prevents coagulation by uniting with and neutralizing the thrombin.

Coagulation of milk consists in the formation of a curd or coagulum which separates from the clear milk plasma or whey that still holds the salts and milk sugar in solution. The coagulum is composed of the comparatively insoluble protein casein and the fats of milk entangled with it. True coagulation of milk is brought about by rennin, an enzyme of the gastric juice. Other curdling agents can also act upon milk, but the changes are not the same. The so-called "spontaneous coagulation" or curdling of milk from souring is not true coagulation, but merely the precipitation of caseinogen. If milk is allowed to stand exposed to the air at a warm temperature, the bacteria producing lactic acid soon decompose the lactose or milk sugar with the formation of lactic acid. When this acid reaches a certain amount, it causes a *precipitate* of caseinogen and fat. True coagulation consists in the conversion of caseinogen into the comparatively insoluble protein casein, but acids do not produce this change.

The action of rennin in changing the soluble protein caseinogen into the more insoluble casein is not a simple one. The caseinogen is split up into two parts: the comparatively insoluble casein which forms by far the greater part, and a very small amount of a freely soluble protein resembling a proteose, called "whey protein" by Hammarsten. The coagulation of milk is analogous to that of blood in that lime salts are absolutely necessary for the chemical changes, and clotting does not occur when they have been removed by dialysis or the addition of a soluble oxalate or citrate. The changes, however, are not identical. In the coagulation of blood the lime salts first combine with two other substances to form thrombin or fibrin ferment, and this then acts upon fibrinogen. Rennin first acts upon caseinogen, even in the absence of lime

salts, to form paracasein or "soluble casein," but no curdling occurs. The enzyme may then be destroyed by boiling, but the addition of a lime salt causes coagulation instantly. The lime salt unites with soluble casein to form insoluble casein.

The caseinogen of human milk is different from that of cow's milk, and forms a flocculent curd with rennet instead of a solid mass.

The curdling ferment of the pancreatic juice produces a peculiar kind of casein, called "pancreatic casein" by Halliburton, which is not the same as that formed by rennet. At the body temperature it forms with cow's milk a granular precipitate and not a coherent clot as rennin does. The removal of lime salts only slightly hinders but does not prevent this curdling. The precipitate differs in its solubilities both from caseinogen and casein, and it can still be converted into true casein by rennin.

Extracts of various tissues, as the testis, muscle, and liver, as well as the juice of certain plants, cause curdling of milk probably in much the same way as does this unnamed ferment of the pancreatic juice.

As stated above, the curdling of milk from souring is not true coagulation. This precipitation of caseinogen, carrying the entangled fats with it, can be brought about by other acids, *e.g.* by the cautious addition of acetic acid. The precipitate resulting from the addition of an acid is usually flocculent and contains less lime than that formed by rennin. It can form even in the absence of free lime salts, and is more easily redissolved than is the curd containing true casein. Moreover, it can be dissolved and recurdled by rennin, *i.e.* converted into true casein. Although true casein can be dissolved, it cannot be recurdled by rennin. This is the most striking difference between caseinogen and casein.

Although the lactic-acid bacilli do not cause true coagulation in the ordinary souring of milk, some bacteria, either by secretory activity or by some product of their metabolism, produce a coagulum which appears to be a true clot. This fact is utilized by bacteriologists to distinguish between different kinds of bacteria, but probably occurs only under ordinary conditions in those exceptional instances when a ropy or stringy clot forms in milk without souring.

Coagulation of Muscle.—Rigor mortis, or the rigidity of death, is due to a coagulation of muscle proteins. If the muscles of cold- or warm-blooded animals be freed from blood and mixed with ice and salt, or extracted with a rather strong solution of neutral salt, a clear muscle plasma containing most of the proteins of muscle can be obtained. By raising the temperature in the one case, or diluting with water in the other, a coagulum consisting of myosin or myosin-fibrin is formed from the proteins that were in solution and separates from a clear serum. Myosinogen (v. Fürth's myogen), a globulin-like body which constitutes about eighty per cent. of the proteins of muscle plasma, is converted into myosin. Paramyosinogen (v. Fürth's myosin), a true globulin which is only one-fourth as abundant as myosinogen, is also contained in the clot. Small amounts of other proteins (myoglobulin and myoalbumin) remain in solution in muscle serum. The formation of myosin is generally supposed to result from the action of a myosin ferment. A coagulating substance can be extracted from muscle in the same way as fibrin ferment is obtained from blood serum. The two, however, are not identical, for fibrin ferment cannot coagulate myosinogen, neither can myosin ferment coagulate fibrinogen. Free lime salts do not appear to be necessary for the formation of myosin.

The theory of a myosin ferment is denied by some physiologists. Starling attributes the coagulation to the development of sarcolactic acid. When the accumulation of sarcolactic acid is prevented by perfusing muscles with salt solutions, the onset of rigor mortis may be postponed indefinitely and muscles putrefy without having undergone rigor.

Myosin is much more soluble than other coagulated proteins resulting from the action of enzymes, and is often classed with globulins because of the ease with which it can be dissolved by saline solutions. Further, the difference between myosin and the mother substance from which it is formed (myosinogen) is not so great as in the other cases. In the coagulation of muscle, $CO_2$ and lactic acid are formed, probably from the chemical changes taking place in the proteins.

The appearance of rigor mortis in the muscles is due to these same chemical changes that have been described in muscle plasma. The rigor often disappears before putrefactive changes appear. A proteolytic ferment has been found in dead muscles, and this is probably greatly aided by the lactic acid in causing the myosin to disappear.

The presence of acids, stopping the blood supply, or heating the muscle will cause coagulation that is often called "acid-" or "heat-rigor." In the cold-blooded frog 40° C., in the mammal a temperature of 48° to 50° C., will cause heat rigor. This is probably only the premature appearance of rigor mortis in the dying muscle. It is entirely different from heat coagulation, as the myosin can be dissolved by solutions of neutral salts, while proteins coagulated by heat cannot. Further, the other chemical changes are the same as in rigor mortis, and the myosin formed is still coagulable by heat. William S. Carter.

**Coagulation Necrosis.**—See *Necrosis.*

**Coagulation Time.**—See *Blood, Examination of.*

**Coagulin.**—If, to a specific immune serum is added a bacteria-free filtrate from a culture of the homologous organism (that is, the same organism that was used to produce the immunity), a precipitate will appear in the mixture. The substance which has been developed in the serum and which calls forth the precipitation is called a precipitin. If now an animal be immunized by injecting it with a soluble protein there will be formed in the animal's serum a precipitin for that protein. Thus precipitins have been divided into two classes, bacterial precipitins and protein precipitins, which latter are also called coagulins. The coagulins behave in every respect like the other precipitins and for a detailed discussion the article on that subject should be consulted.

Coagulins are antibodies of Ehrlich's third order and contain two groups, a binding group and a function group. The function group is destroyed at a temperature of from 65°–70° C., while the haptophore portion of the body is uninjured. Such an altered antibody is called a coagulinoid. Aside from their position among the antibodies and their relation to them, which is discussed in the article on *immunity*, the chief interest in the coagulins lies in the use which has been made of them to identify blood in the interest of justice, and meats in the interest of pure food. For instance, if a stain is believed to have been made by human blood, a rabbit is immunized against human blood serum. A salt solution extract of the stain is prepared and some of it is mixed with serum from the immunized rabbit. If a precipitate is formed and the suitable controls react properly, then the stain can be said to consist of human blood. The coagulins are quite markedly specific and the test shows questionable results only when the material for the test has been derived from an animal closely related biologically to the one from which material was obtained for immunization. Thus an antiserum for human blood will react also with the blood of the anthropoid ape, though only in lower dilutions, and it is by the use of various dilutions that differentiation between them may be made. Ralph G. Stillman.

**Coal Gas.**—See *Gas, Illuminating.*

**Cobbold, Thomas Spencer.**—Born in Ipswich, England, in 1828. He received the degree of Doctor of Medicine from the University of Edinburgh in 1851, and at the same time was awarded the gold medal offered as a prize by the Faculty. After graduation he devoted himself for several years to the study of comparative anatomy and zoölogy, under the guidance of John Goodsir, whom Virchow, in the preface to his work on Cellular Pathology, characterized as "one of the earliest and most acute observers of cell-life." In 1873 he was made at first an Instructor of Botany, and shortly afterward Professor of Helminthology, in the London Veterinary College. He died in London on March 20, 1886.

Cobbold ranks as one of the highest authorities in the department of helminthology. The following are the titles of a few of his more important published writings: "Entozoa; an Introduction to the Study of Helminthology, with Reference more particularly to the Internal Parasites of Man," London, 1864; "On the Present State of Our Knowledge respecting Entozoa which are either known or are presumed to be introduced into the Human Body by the Consumption of Animal Food," London, 1865; and "The Internal Parasites of our Domesticated Animals, a Manual of the Entozoa of the Ox, Sheep, Dog, Horse, Pig, and Cat," London, 1873. A. H. B.

**Cobra.**—The name given to certain very poisonous snakes of the genus *Naja* found in India and other countries. These snakes have grooved, not hollow, permanently erect fangs. A. S. P.

**Coca.**—*Erythroxylon.* The dried leaves of *Erythroxylon coca* Lam. (Fam. *Erythroxylaceæ*), known commercially as Huanuco coca, or of *E. truxillense* Rusby, known commercially as Truxillo coca, and yielding, when assayed by the U. S. P. process, not less than 0.5 per cent. of the ether-soluble alkaloids of coca.

Owing to their important bearing upon the value and uses of this drug, we find it necessary to discuss in some detail portions of its history which in the case of most drugs are practically unimportant.

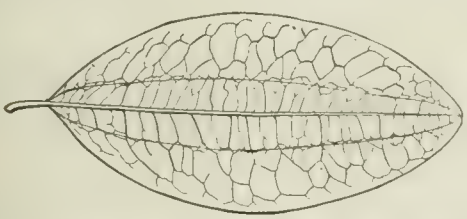


Fig. 1441.—Huanuco or Bolivian Coca. (*E. Coca* Lam.) Natural size.

The different varieties of the coca leaf vary in qualitative action to a degree not recognized in our best text-books and appreciated by very few practitioners. Huanuco coca is also known as "Bolivian," or "Large Brown" leaf (Fig. 1441). Of this there are noticeable forms or grades, but these may be regarded as differing in degree rather than in kind. Thus, the best Bolivian (Yungas) leaf is rather smaller than the same grown in Peru. The term "Peruvian" is too indefinite for use, as it may reasonably be applied to either this or the Truxillo variety. When we have quite finished with Huanuco coca, attention will be given to the Truxillo variety and to other species of the genus.

Origin.—There is no reasonable doubt that both species originated upon the eastern slope of the South American Andes, probably in Peru. Since coca was cultivated in prehistoric times, there is no way of certainly ascertaining whether it was wild in its present form or whether the latter is a product of development by cultivation from some other wild form. The latter is probably true, because in the wild (escaped) state it shows a strong and rapid tendency to lose its characteristics. It is impossible to say of any of the wild plants collected by the writer and others that they are not escapes from cultivation, many known to be such having been encountered. Lastly, it is not known whether the ancestral form is one of those still in existence in a wild state.

History.—The coca plant was under cultivation at the time of the discovery, and no clew to its introduction to cultivation could then be, or has since been, obtained. It occupied an important place in the religious and mythological history of the people. This is of interest here only because of the unquestionable fact that such esteem was the result of an appreciation of its useful properties, rather than, upon the contrary, and as for centuries believed, the superstitious reason for its being used. We may therefore dismiss its mythical history (see "Coca at Home and Abroad," *Ther. Gaz.*, March and May, 1888, also p. 14, 1886) as being here unimportant, and consider its physiological and therapeutical history. Its expectorant, sialagogue, stomachic, carminative, emmenagogue, and aphrodisiac properties are among the minor ones for which it was and is used by the natives. As a stomachic, it is recognized that its use before meals detracts from the appetite, but that its use thereafter relieves any discomfort resulting from excess, while not appreciably inhibiting digestion. In fact, its general repute is that of aiding digestion. The more important objects of its use are as a limited cerebral stimulant, an anesthetic, a very peculiar muscular stimulant, and an ordinary masticatory. As a cerebral stimulant it filled the place of coffee. It was used before the latter was introduced, and after that event it continued to be used by the natives, while the much more expensive coffee was used by the foreign element. In this direction its characteristics were to promote cheerful and hopeful views and sentiments, without excitability, but rather with increased calm. As an anesthetic, its use was a general more than a local one, though it was locally applied to ease pain, and its carminative and stomachic uses were clearly of this nature. The object of overcoming the pains of hunger and of fatigue was preeminent, while that of securing relief from pain by a mild general anesthetic, in spite of increased wakefulness, was general.

The term "muscular stimulant" is not accurate, but is used for want of a better. More lengthily stated, the plant was used to enable man to perform more labor with less fatigue and with less nutrition. Without regard to the facts of the case, this was the belief of its users. In consequence of these effects, bodily or mental, they performed almost incredible physical tasks, long-continued, upon a food supply, the scantiness of which is equally astonishing, and with results not injurious beyond causing temporary inconvenience. The special adverse conditions to be met in these efforts were the continued scaling of steep and high acclivities, with little food and with a very scanty supply of oxygen, and under the necessity of either attaining a high speed or transporting heavy loads.

The above statements, in substance, were among the earliest historical records promulgated concerning its use by the people of the countries concerned, and they have been repeated, with assurance, by all subsequent investigating travellers. Many of these travellers went to extraordinary lengths to test their accuracy, and always with affirmative results. Travellers and foreign residents verified them by personal experience and very frequently relied upon

them for personal help. These assertions were met abroad by religious opposition because of the heathen relations of the coca customs, by very great professional conservatism, and, lastly, by discredit because the leaves, exported for use, largely failed, in the condition in which they were received, to verify them. All the present important uses of the drug in its own form, or in that of cocaine, cannot be said to cover the same ground involved by the native uses of coca leaves. There appears to be but one rational explanation of this broad discrepancy, namely, changes in properties which the leaves undergo after being dried. This view has been verified by the writer by numerous assays of the leaves soon after collection, compared with others made later. Preparations made upon the spot have also been found, by extended trial, to act more like the leaves as chewed by the natives than like preparations made from the exported leaves.

The details of the method of use have been so often published that any account of them appears scarcely necessary in this article. The use of *Llipta*, or ashes, with the bolus is to be regarded partly like that of condiments, especially of salt as such, without food. At the same time, the suggestion made by Holmes that the effect of this alkali is to decompose the alkaloid, cocaine, developing new constituents which exert the desired physiological action, is full of food for thought and experiment.

Cultivation and Production.—The product in use proceeds wholly from cultivated plants. Leaves from wild plants are unfit for use. Its cultivation is generally like that of the coffee and tea shrubs. Details will be found in the article last cited. Cultivation is very extensive in Bolivia, whence large quantities are exported to Peru for native use, in addition to the large quantities there produced. The annual consumption is to be stated in tens of millions of pounds. Upon the western continent, it is comparatively little grown outside of the two countries named, although considerable (mostly of the Truxillo variety) is grown in Ecuador, Colombia, Venezuela, and Brazil. Java has come to be a large producer of a peculiar variety, mostly used by the alkaloid makers. There is no point in the United States where the climate would admit of its being grown satisfactorily, though it would probably do well in the mountains near Santiago de Cuba.

*The Coca Plant.*—The shrub grows from five to eight feet high and is widely branched. The trunk may ultimately attain a thickness of four or five inches, and it, with the larger branches, soon becomes shaggy with gray lichens. The twigs soon become scaly with the closely set, stiff, almost spinose persistent stipules, and are densely leafy toward their ends. The small white or cream-colored flowers grow in little fascicles, close against the bark, on the older and leafless parts of the twigs. They are followed by an investment of ovoid, slightly inequilateral, smooth drupes, which become about a fourth of an inch long and of a deep-red color. The first crop of leaves can be gathered at about two and a half years from seed, and the shrubs bear well for twenty or thirty, or even forty, years. There are no definite months for picking, the condition of the leaves determining the time. Their development at the tip of the twig is continuous, and if allowed, they would as continuously fall off below, but they are picked just in time to avoid loss from this cause. The shrub yields two or three, or sometimes even four, crops in the twelve months. They are picked by hand and immediately dried in the sun upon smooth floors of hard clay, or preferably of flat stone. As the upper layers dry the lower must be continually stirred up. Not even the slightest amount of rain must be allowed to fall upon them. Hence men stand always ready with huge brush brooms, and upon the slightest indication of rain sweep them through the immense doors of the buildings which surround the drying-floor. A few hours of hot sun is sufficient to dry them, but they must be kept in the houses for two or three days to undergo a slight sweating process. When this supplementary moisture has dried, they are pressed very tightly into small bales, called *cestos*, and are ready for marketing. The tight pressure is as much to exclude the moist atmosphere as to secure convenience. For transportation across the mountains and export they are encased in oil cloth or rawhide. Upon being opened, the few outer layers may be found discolored, but if properly dried and packed it is rare that the remainder undergoes any conspicuous change. Yet a slow deterioration commences at once after drying. No matter how carefully they are kept, the chewers prefer them in proportion to their freshness. After being kept for a very few months they will scarcely be accepted for native use, and these leaves, which the natives would reject, are the only ones which are ever used by us for medicinal purposes. The chemical nature of this change has never been determined, though the writer has demonstrated that it is due to only a slight extent to the loss of cocaine, which is clearly not the constituent which the native chewers find most efficacious, a fact to be borne in mind in connection with their use of alkali, as referred to above. Neither is it true, as has often been suggested, that this native preference is due to differences of savor merely.

Aside from the method of chewing, which is despised by the better classes, large quantities of the leaves are prepared in the form of a sort of fluid extract or cordial for use as a liquor or *pousse café*.

Coca paralysis or coca mania, which has frequently been discussed in a somewhat sensational way in the medical press, and which has been compared with cocainism, is so rare, at least among the Bolivians, as to be almost a fiction. The writer was never able to find a case or any authenticated account of one. Nevertheless it is not unlikely that such do occur.

Description of Drug.—The leaves of the Huanuco variety occur in a yellowish-brown to brown mass, a distinct green color being rare, and even a distinct green tinge to the brown being oftener wanting than present. Much of the quality is to be determined by the color characteristics. A very young, and therefore inferior leaf, is more apt to retain the green color. A badly cured or preserved or very stale leaf will be of a dark brown. If only stale this brown will be uniform and dull; if badly cured, it will be smudgy and patchy and of a stained appearance. The perfect leaf will be of a rich, light, clear brown, with more or less of golden or greenish tinge, never bright green, and with a slight luster. They are mostly flat and unbroken in the best preserved samples. They have a very short, stout petiole. The blade is from 2.5 to 7.5 centimeters (1 to 3 in.) in length, and a very little more or less than half as broad. It is oval in outline, a very slight point at the apex and a very short abruptly narrowed basal portion, the length of which is not more than one-twelfth of the entire blade. Except for this portion and the slight tip, the outline is an almost perfect ellipse. The margin is quite entire, the surface smooth, the body thickish, the consistence somewhat tough and slightly leathery. The midrib is very prominent below, traversed by a narrow ridge above. The venation markings are rather obscure on both surfaces, especially above. Upon the lower surfaces two characteristic lines are prominent, known as the "lateral lines." They run at a little more than one-third of the distance from the midrib to the margin, and terminate at both ends, not in the midrib, but in the margin, at a slight distance from it. They are not veins, but consist chiefly of collenchyma cells, and are to strengthen the edges of the folds, in the bud. The surface enclosed by them is of a lighter shade than that outside, and is known as the "areola." The more

highly cultivated and finer and richer the leaf, the more conspicuous are these lines. As the plant escapes and retrogrades in the wild state, these lines appear less conspicuously in the dried leaf, which becomes thicker, browner, more veiny and rougher of surface. The foregoing is a description of the typical leaf, as grown in the Andes and some other parts; it varies with the narrowed basal portion longer, but always much less than half the length of the leaf, and the leaf never narrower than obovate. It also varies to paler, but is never of a pale senna-green color, like the next variety. The apex is often very slightly retuse, and the midrib produced into a slight apiculation or mucronation. The faint odor has been denominated "tea-like," but it is characteristic of coca. The taste is slightly bitter and barely aromatic. The bitter taste is greater in poorly cultivated and in wild or shade-grown leaves. A little while after chewing anesthesia of the tongue and lips occurs. Experience can enable one to estimate almost exactly the percentage of cocaine by the degree of this effect.

Some other leaves are occasionally chewed by the natives when coca is not obtainable, purely as a masticatory. One of these is apparently a Mimosea, and is called "Chiuchi-coca." None of these is observed in our drug, which is not likely to be adulterated nor substituted by anything except another variety of coca.

Composition.—The alkaloid *cocaine* is, in professional medicine, the important constituent, and exists to the extent of one-half to nine-tenths of one per cent. This alkaloid is considered in a separate article. Since it is a *methyl-benzoic acid* compound of the alkaloid *ecgonine*, it is not surprising that the latter alkaloid should be encountered in the drug, both free and in combination with various other substances. Neither the constancy nor the percentage of these, nor the resulting modification of the drug's action, has been investigated or much considered. With these alkaloids, there is a little tannin and wax and a very slight amount of an aromatic principle.

Action.—So far as medicinal practice and literature are concerned, the action of cocaine is that of coca, and will be considered under the title of *Cocaine*.

That the two are the same in action is assuredly not true, but the differences between them and the action of the other alkaloids are subjects which have not been suitably investigated, the assumption generally prevailing that they are practically the same. No differences can be expected between cocaine and coca as it reaches us, with cocaine as the chief constituent, which can be compared with those between the alkaloid and the leaves immediately after they are collected and dried, for careful drying effects scarcely any change in their composition or activity. In spite of this fact, it is unfortunate that the action of our leaf preparations should not have received more study. The fluid extract, of which the dose is fl. ʒ ss. to i., (2.0-4.0) and the 6.5 per cent. wine (dose fl. ʒ iv, or 16 c.c.) are official.

*The Coca Habit and Coca Poisoning.*—Although these result in almost all cases from the alkaloid, cocaine, yet both may result from preparations of the leaves, the use of which should be as carefully guarded as that of cocaine. The nature and symptoms are the same as when resulting from the alkaloid (see *Cocaine*).

Other Varieties and Species.—The genus *Erythroxylon* is one of two in the family *Erythroxylaceæ*, and it contains about 140 species, for which more than 170 names have been proposed. About one-sixth of the species are foreign, the others natives of tropical American countries. Cocaine, or at least some principle having slight locally anesthetic properties, pertains to several species, but in only three are they of practical importance. Of these the principal one has been considered above. That next in importance is *E. truxillense* Rusby (*Druggists' Circular*, 1900, p. 223), or the Truxillo, or "Small Green" leaf. It was called *E. coca spruceanum* by Burck, but is a distinct species, and there is already an *E. spruceanum* Peyr. This is the leaf chiefly cultivated in Northern Peru, Ecuador, Colombia, Mexico, and Brazil. It is not the one commonly spoken of in English journals as the Truxillo leaf. According to Burck, it is also the leaf cultivated in Java and is sometimes written of as the "Java" leaf. Its most distinctive characters are its uniformly small size, pale, senna-green color, thin and brittle texture, and tapering base. It varies between obovate and oblanceolate, the lower half tapering gradually, and is about two-thirds the size of the Huanuco variety. The apex may contract abruptly into a short point, or be slightly emarginate, then apiculate. It is exceedingly thin and brittle, and occurs much broken. Its color and general appearance at a distance are those of India senna. Most of the leaves, in the dry state, are wanting in the lateral lines, and when these are present they are quite indistinct. The mode of cultivation and packing of this variety are about the same as of the other, but it does not bring so high a price. The published statements as to its composition are very contradictory. Its yield of total alkaloid has been placed as high as 2.25 per cent. This alkaloid, however, differs greatly in kind from that of the official leaf. Instead of cocaine it consists, to a very considerable extent, of cinnamyl compounds of ecgonine. It yields a much larger percentage of truxilline (isotropylcocaine) than either of the others, with benzoylpseudotropeine. Of these, the former is believed to be poisonous, while the latter is less poisonous and acts very much like cocaine. Certainly, manufacturers find it impossible to produce from it an equal quantity of cocaine except by the conversion of the other alkaloid into it, by artificial means. This, however, affects the manufacturer alone, for it by no means follows that it is inferior for medicinal use. In fact, the use of the fluid extract prepared from this variety has been found by many physicians to produce better results than the use of that from the other variety. This, it may be remarked, is quite in keeping with several other indications already mentioned, that much of the physiological action of coca is not referable to its cocaine. It appears to be the benzoyl-ecgonine which produces the stimulant effects, while lacking the anesthetic properties.

Fig. 1442.—Truxillo Coca. (*E. Truxillense* Rusby.) Natural size.

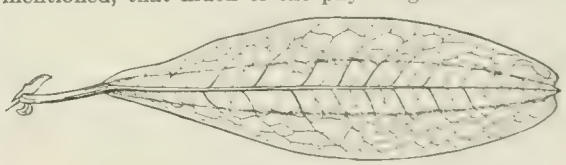


Fig. 1443.—*E. Carthagenense* Jacq. (?)

There is a third variety of the coca leaf, known in English journals as the Truxillo leaf, but never seen in the New York market, where the Truxillo leaf is an important article of commerce. It has been called by Morris "*E. cocoa nova-granatense*," but there is little doubt that it is one of the first described species of Erythroxylon, namely, *E. carthagenense* Jacq. It appears to be native in Colombia, and largely cultivated in the British provinces, whither all the stock was sent from a single plant cultivated in the Kew Botanical Gardens. The leaves (Fig. 1443) are about two, or even three inches long by one-third as broad, oblanceolate, with a very long tapering base and a rounded, mostly emarginate, then mucronate

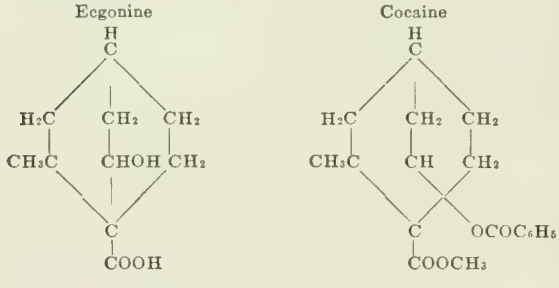
summit. They are pale and thin, and the lateral lines and areola are very well marked. Their composition is very similar to that of the Truxillo leaves, though it is said that the isotropyl-cocaine is wanting, or present in slight amount. There appears so far to be no good reason why they should not rank with the Truxillo leaves as a medicinal agent, though much fuller information concerning them is required.

HENRY H. RUSBY.

**Cocaine** (*Methyl-benzoyl-ecgonine*) $C_8H_{13}(C_6H_5CO)$-$ON.COOCH_3$.—The origin of cocaine is sufficiently explained in the preceding article on *Coca*. It was first isolated by Gardeka in 1855, and by him named erythroxyline. Niemann, who renamed it cocaine, gave much fuller information concerning it. It was many years after its discovery before its physiological action was thoroughly investigated, although its benumbing power and its action in dilating the pupil were early made known. About the year 1880 many important reports concerning it began to appear, and its remarkable uses in ophthalmology began, in 1884, to be developed. The first productions were extremely expensive, selling as high as three dollars per grain, with a steady reduction to a little more than one cent per grain five years later. Coincident with these high expenses of manufacturing, the processes of purification were imperfect, and led to many serious accidents in the application of the drug to the eye, and to misinterpretations of its normal action. A high degree of purity should be required in this article.

In spite of the very extensive use of eucaine and orthoform, which act similarly, and in some respects preferably, to cocaine, the consumption of the latter is enormous. Various natural products, such as erythrophleine, have been proposed as substitutes, but their action is far from being as satisfactory. Originally, all cocaine was extracted from the leaves in this country and Europe, but more recently economies in transportation and the avoidance of damage to the leaves in transit have led to its extraction at the points of production in Peru and Bolivia, and its subsequent purification here and in Europe.

CHEMICAL CONSTITUTION.—Cocaine, if heated with hydrochloric acid, splits into benzoic acid, methyl alcohol, and a new alkaloid, ecgonine ($C_9H_{15}NO_3$), of not well-pronounced physiological action. As was to be expected, there is an intimate connection between the constitution of the cocaine molecule and its physiological action. There exists quite a series of bodies similarly constituted, with analogous physiological action, facts that have been studied by Ehrlich and E. Poulsson. Ecgonine is a carbonic-acid derivative of tropine, and cocaine represents ecgonine with one hydrogen atom replaced by a benzoyl ($C_6H_5COO$) group and another by a methyl group as given below




The hydrogen atom replaced above by the benzoyl group can be replaced by other acid radicals: (*e.g.* valeryl, cinnamyl, or phenyl-acetyl) while instead of the methyl group, ethyl or other similar radicals can be used, giving rise to bodies of similar constitution and physiological action. Experiments with a number of these cocaines and their components have shown that the alcohol radical above mentioned is essential for the anesthetic effect, and that with its removal from the cocaine molecule the anesthetizing and poisonous properties disappear (Poulsson).

The description of cocaine is as follows: Large, colorless, four-sided or six-sided, monoclinic prisms, having a slightly bitter taste, and producing on the tongue a temporary numbness. Soluble in 600 parts of water, 5 parts of alcohol, and in 3.8 parts of ether at 25° C. (77° F.); very soluble in chloroform and warm alcohol; soluble in 260 parts of water at 80° C. (176° F.); soluble in benzine, carbon disulphide, and ethyl acetate, in about 14 parts of oil of turpentine, and in about 12 parts of olive oil; insoluble in glycerin. It melts at 98° C. (208.4° F.), and should leave no residue on ignition. If an alcoholic solution of cocaine be carefully neutralized with hydrochloric acid, and the solution evaporated to dryness, the residue should respond to the reactions and tests for cocainæ hydrochloridum.

The physiological effects of cocaine are as follows: Locally, after a slight temporary irritation, it produces anemia and anesthesia. If applied to the eye, cloudiness of the cornea, perhaps with dotted erosions, is likely to occur. Winking is diminished and there is arrest of lacrimal secretion. The special senses are blunted similarly to general sensation, though not so strongly. There is, for example, a blunting of the sense of taste, but this is not so marked as that of the nerves of sensation in the mouth. Secretion is also checked for the most part, but this effect also is milder than that upon sensation. Thus, in case of discomfort from over-eating, cocaine will do much to give relief, at the same time that it will not materially check digestion. It often acts as an antiemetic. Upon the mucous membrane of the nares it produces powerful anemia and arrest of secretion, but later there is a reaction. Its continued local application there produces a continuous weak watery discharge from the nose. It markedly increases respiratory action, although the relief from dyspnea secured by it is partly due to sensory depression, and still more to cardiac stimulation. It normally increases both the rate and the force of the heart beat, and it increases blood pressure. Its effects upon temperature do not seem to be perfectly understood. With an increase in both circulation and respiration we should expect elevated temperature, but this is only slightly seen under normal conditions, and the effect in abnormal states has not been well determined. Cocaine is distinctly diuretic, its action reminding one of that of caffeine, though in lesser degree. In ordinary cases it promotes the muscular activity of the intestines, but its habitual excessive use results in abnormal relaxation. The effect upon the skin is somewhat diaphoretic.

It is upon the nervous system that cocaine exerts its principal effects, and it is these which have been most studied. In general, its direct effect upon all protoplasm is first to stimulate or irritate and then to paralyze, and these effects are specially marked in case of the nervous tissues. It has been specially noted that in the eye the anesthesia precedes the anemia. Here it also acts as a mydriatic. Keller has shown that the cloudiness of the cornea is partly due to excessive evaporation.

In acting upon the nervous system, the order, both in time and intensity, is from periphery to center, and from sensation to motion. It appears to have less direct effect upon the tissue of motor nerves than upon that of sensory nerves, but it affects the motor functions through its paralyzing action on the centers. The vasomotor nerve endings are very strongly excited and the reaction is long deferred. It is also to be noted that the paralyzing action upon motor centers is commonly preceded, in overdoses, by a stage of irritation so great as to produce convulsions.

These are often of great severity and are frequently unilateral. The convulsions are tetanic and opisthotonic. Their primary character is proved by the fact that if poisoning is very prompt and severe they may be entirely absent, paralysis being immediate. The effects of cocaine upon the intellectual functions are markedly and agreeably stimulant, much resembling those of caffeine. The drug induces sleeplessness, mental activity and cheerfulness, facts which largely explain the dangerously seductive nature of this drug as a habit former.

THERAPEUTIC USES.—Owing to its pronounced toxicity and to the extreme danger of the formation of a habit, cocaine is seldom given internally at the present day, its application being almost entirely as a local anesthetic. In this respect, despite the introduction of eucaine, novocaine, stovaine, and other succedanea, some of which have manifest advantages, cocaine still maintains its superiority over all other drugs of its class.

*Eye Surgery.*—Cocaine is used here for a threefold purpose: As an anodyne in painful affections; as a local anesthetic in eye operations; as a dilator of the pupil. Owing to the short duration of the cocaine anesthesia (about fifteen to twenty minutes), its use as an anodyne is a limited one. Naturally, it would be most useful in pains caused by superficial erosions or ulcers of the cornea, but even here its depressing effect upon the vitality of the cells makes its repeated or prolonged use inadvisable. It is found useful in the examination of an eye, where pain, photophobia, and lacrimation would otherwise render such an examination almost impossible, but in pains which might possibly be of glaucomatous origin the use of cocaine should be avoided, as it may hasten the development of a glaucomatous attack previously threatened (Javal). Supraorbital or infraorbital neuralgia can frequently be successfully (but dangerously) combated by hypodermic injection.

The use of cocaine as a local anesthetic in eye operations is a very extended one and it has reduced the employment of general anesthesia by ether or chloroform to a minimum. While operations on the conjunctiva and on the cornea can be made perfectly painless by instillation of cocaine solutions, such operations in which the iris is touched or cut, as iridectomies and operations for cataract, cannot always be rendered perfectly painless by instillation, owing to the difficulty of making the iris sufficiently anesthetic. For making the iris anesthetic through instillation into the conjunctival sac it is necessary to begin from twenty to thirty minutes before the operation, and continue instilling every five minutes. A more certain result is obtained by instillation of a cocaine solution into the anterior chamber after the corneal section. Far superior is the method of subconjunctival injections recommended by Koller first for operations on the tendons and muscles and later for cataract operations, iridotomies, and iridectomies.

The *mydriatic* property of cocaine is sometimes taken advantage of in connection with its anesthetic action, and it is often of value in ophthalmoscopy. While the dilatation is sufficient in the dark chamber to allow a satisfactory examination, it does not have the blinding effect of belladonna, the pupil all the time responding to light. This is due to the fact that cocaine dilates the pupil by constricting the blood-vessels of the iris, but leaves the sphincter intact. Besides, the accommodation is hardly interfered with.

*Rhinology and Laryngology.*—In the examination and treatment of the nasal cavities cocaine has an extensive field of usefulness. By its power of constricting the blood-vessels it causes the mucous membrane to shrink whereby inspection of the posterior parts is facilitated. This effort is greatly increased by combination with adrenalin. Medicated applications and the actual cautery or caustics can be employed painlessly. In reflex neuroses starting from the nose the exact locality of the trouble can be detected, inasmuch as by application of cocaine to the starting-point the patient is temporarily relieved (asthma, mimic spasm, etc.). In hay fever it affords relief but has no curative power, and its use in this affection is to be condemned because of the great liability of the patient to become an addict. The solution is applied either as a spray by means of an atomizer or with a cotton wad on the point of a probe. For spraying, only weak solutions (two per cent.) should be employed. For application with brush or cotton stronger solutions (five or ten per cent.) may be used. For making the vocal cords anesthetic very strong solutions are required.

*Otology.*—Comparatively little advantage has been brought to otology by the use of cocaine. The drumhead (covered with epidermis) can hardly be rendered completely anesthetic, but the sensibility can be lessened by repeated application of a warmed fifteen- to twenty-per-cent. solution (Hedinger). In operations in the tympanic cavity more can be expected from the anesthetic effects of the drug, although only if the operation is limited to the mucous membrane. Catheterization of the Eustachian tube is facilitated and made painless. Hedinger has reported favorable results in cases of inflammation of the middle ear. A few drops of a two- to four-per-cent. solution blown into the Eustachian tube through a catheter in most cases suffice to stop the pain for several hours. Kiesselbach had good success from insufflation of a few drops of a four-per-cent. solution into the Eustachian tube in cases of subjective ear noises.

*General Surgery.*—The use of cocaine in general surgery is very extended, though much less so now than before the introduction of its synthetic rivals. For a discussion of its employment for minor purpose, see the article *Anesthesia, Local.* In genitourinary surgery cocaine is extensively used, usually in combination with adrenalin.

*Dentistry.*—To make extraction of teeth painless it is not sufficient to brush the solution on the gums, as this does not make the alveolus anesthetic. Even injection between gum and alveolus in one place only will frequently fail, and it is often necessary to inject the solution under the gum in several places inside and outside the tooth sockets. A five-per-cent. solution is sufficient, and not more than half a grain of cocaine should be used. Even then one must expect to encounter a larger number of cases in which constitutional symptoms occur than are observed in other branches of surgery.

*Gynecology.*—Apart from the use in minor operations on the vulva, vagina, and the cervix, cocaine is especially valuable in the treatment of dyspareunia and vaginismus. Relief of the latter may often be obtained by the injection of twenty to thirty minims of a one-per-cent. solution in oil or liquid paraffin.

*Dermatology.*—Cocaine does not have any effect if applied to the unbroken epithelium. If the latter is macerated or wanting, solutions or ointments can be used to combat itching as in vesicular eczema, especially in the itching eczema of the genitals, in painful ulcers, and after cauterizing. In different operations on the skin, and before cauterizing, the application is the same as described in the article on *Anesthesia, local.* It is of interest to note that cocaine, like other substances, can be driven into the skin by the electrical current if applied to the positive pole—cataphoresis. The anesthesia thus engendered may be used for superficial operations.

In *general medicine* much was at first expected from the stimulating powers of cocaine upon the physical functions, but its internal use is too dangerous to be justifiable.

In whooping-cough, applications of two- to five-per-cent. solutions to the tonsils, pharynx, and epiglottis have been used with good result. Various

neuralgias and the shooting pains in locomotor ataxia may be controlled sometimes by the subcutaneous application of cocaine. In tabes, cocaine in doses of gr. $\frac{1}{3}$–$\frac{1}{2}$ (0.02–0.03) is reported to have succeeded in cases in which morphine did not have the desired effect.

*Dose.*—Internally one-third to one grain (0.02 to 0.05) may be considered a safe dose, and even 0.1 gm. may be given, but the continued internal use in any dose is to be condemned. Locally, weak solutions of one per cent. and two per cent. should be used, well distributed over the field of operation. For spraying (nose, throat) weak solutions (two per cent.) should be used in known quantity. For operations in nose, pharynx, and larynx, brushing with strong solutions cannot be avoided, but in these cases the danger is obviously less because the quantities used are small. Careful watching of the patient and gradual administration in all cases will increase the safety of continued administration.

Cocaine Poisoning.—Both acute and chronic poisoning by cocaine have been very common, but the latter is by far the more serious consideration.

*Symptoms.*—The diversity observed in the symptoms of *acute poisoning* may appear strange until it is remembered that the primary and secondary effects of the drug are largely contradictory, and that either may be more prominent, according to the conditions of the case. Cases of slight poisoning, which are the commoner, offer the following objective symptoms: Pallor, cold perspiration, frequent pulse, and dilated pupils. Subjectively, the patient complains of dryness of the throat and lips, a feeling of heaviness in the limbs, and weakness, or even vertigo, the latter symptoms apparently due to cerebral anemia. This condition does not last long, and after a short time (one-half to one hour) complete well-being sets in, even if no restoratives are used. In another class of more serious accidents great mental excitement, with talkativeness, hallucinations, and even delirium, may be present. On the other hand, conditions of syncope and collapse may prevail. In the gravest cases, painful dyspneic breathing, clonic and tonic convulsions occur, which may cause death by tetanus of the respiratory muscles; or death may result from paralysis of respiration and heart without preceding convulsions. Poisonous absorption is more apt to occur from operations upon the head than elsewhere, and tends to be favored by the sitting position.

The time of appearance of poisonous symptoms varies, being five to ten minutes on the average; sometimes they appear immediately after administration, or after a few seconds, sometimes only after one-fourth or even one-half hour. In the following, symptoms of poisoning are given as collected by Mannheim from the various cases.

General Symptoms.—The patients become sleepy and almost lose consciousness and faculty to articulate, or they fall within a few minutes into a very deep sleep of comatose character. Severe collapse has been observed. In other cases the patients become very restless and excited, cry and laugh alternately, gesticulate, and their gait becomes unsteady, like that of a drunken person. There may be sleeplessness, lasting from thirty to forty hours; afterward complete forgetfulness of what has happened.

Nervous System.—In mild cases the reflexes are increased; in severe cases there are epileptiform attacks, with general clonic convulsions, tetanus, opisthotonus, death.

General sensibility is diminished; sometimes there is only numbness, sometimes complete anesthesia. There is a feeling of intense coldness in the anesthesic parts, or various paresthesias. Twitching of single muscles, or general convulsions may occur; in other cases, heaviness or tired feeling in the limbs, sometimes aggravated to apparent paresis.

The pupils are dilated, or sometimes much contracted; reacting in some cases, in others motionless. There may be dimness of vision or complete amaurosis. Buzzing in the ears may occur and various disturbances of smell and taste.

Respiration is short, whistling, laboring and there may be dyspnea. The frequency may diminish (even to nine respirations in the minute) and may even cease, so that death occurs by asphyxia. The pulse is much accelerated, often very weak, filiform, irregular; in other cases the pulse is less frequent.

Organs of Digestion.—Numbness of the throat, astringed sensation and dryness in the pharynx, dysphagia; burning pain in mouth and stomach (even after hypodermic administration); pain in intestines; rectal and vesical tenesmus.

*Cause of Death.*—Paralysis of the respiratory and vaso-motor centers and heart, whereas in other cases death results from tetanus of the respiratory muscles.

*Autopsy* shows intense hyperemia of the brain and of the inner organs.

*Fatal Dose.*—Mannheim, who has studied this subject with care, regards one gram (fifteen grains) as about the fatal dose.

*Treatment.*—In the minor cases, in which weakness and dizziness prevail, a horizontal position of the patient and administration of stimulants, like brandy, coffee, ether, are the reasonable measures to be taken. Inhalation of a few drops of amyl nitrite or the use of nitroglycerin has been recommended, and is the measure generally adopted to combat the supposed anemia of the brain. For the severe cases in which convulsions occur, resource may be had to ether or chloroform to prevent tetanus of the respiratory muscles, which is the most frequent cause of death. After the first grave and imminent danger has passed, chloral can be given. If respiration stops, artificial respiration must be resorted to. The cautious use of atropine is often of service.

*Chronic poisoning* is best considered under the head of the cocaine habit.

Cocaine Habit.—The cocaine habit has come to be one of the most common and destructive vices known in this country, and its eradication has become an object of concern to and oflegislative action by cities, States, and the Federal Government. Many of its victims have been opium or morphine users who have grafted the cocaine habit thereon, perhaps for the purpose of effecting a cure. Very many have formed the addiction through the use of catarrh remedies which, in most cases quite unknown to the users, have contained cocaine. Other proprietary medicines containing it have been similarly taken in ignorance of their dangerous character and the patient has suddenly found himself a slave to the habit. In another very large class of cases the subjects, often knowingly, have indulged in the use of cocaine for its stimulant effects, just as they might in other narcotics. By far the saddest cases are those in which children have been led to form the habit by human degenerates, the latter often peddling the drug in the vicinity of public schools. As a result of this variable nature of the cases, as well as of the irregular nature of the drug's action, the symptoms of chronic poisoning exhibit wide variation.

By virtue of its peculiar seductiveness, cocaine stands out prominently from all other habit-forming drugs. In its power to relieve bodily fatigue and to promote physical activity and apparent energy, it rivals strychnine, while it is equally efficient with caffeine in dispelling depression of spirits and in promoting mental activity and cheerfulness. Unlike both of these drugs, however, and in fact all others, reactionary symptoms do not immediately follow, so that the subject is free from that blessing of punitive restraint that is the great general safeguard of humanity. As a rule, he scarcely feels his bonds until they

are so strongly fastened that escape is difficult or impossible.

The general effects of cocaine upon the intellect may perhaps be best defined by saying that it tends toward true insanity, the usual type being a compound of melancholia and paresis, but not infrequently being maniacal. The initial stage is almost always that of insomnia and general nervousness, always accompanied by loss of appetite, indigestion, and malnutrition. This state is soon accompanied by physical lassitude and unconquerable indolence, and incapacity as well as disinclination for consecutive effort of either body or mind. Melancholic symptoms then quickly supervene. Not only does the subject become insanely suspicious, but he himself becomes untrustworthy. He indulges secret vices, becomes secretive and untruthful, loses general moral sense, and, above all, becomes insensible to the serious results to flow from his immoral or criminal acts. Thus, the wave of crime that some years ago swept over the negro population of the southern United States followed directly upon the widespread prevalence of the cocaine habit among them, and there seems little doubt that the latter was an important factor in its production. Soon, hallucinations and illusions, following upon delusions, and maniacal outbreaks often occur and the victim becomes a subject for asylum treatment.

The physical symptoms are all those of progressive deterioration, with the nerve centers obviously the seat of attack, and malnutrition as the medium of destruction.

The *treatment* of this condition calls for the most watchful care of one experienced in such work. Even at the best, success is doubtful. The subject should be so placed that he is under the absolute control of the physician. When the habit is but lightly formed, the use of the drug may be abruptly discontinued. In most cases, however, this must be done more or less gradually, as the conditions indicate. There is very little to be hoped for from the use of drugs, except for controlling general conditions. The restoration of normal and healthy physical and mental action is to be sought, rather than the direct removal of abnormal conditions. If emaciation can be checked and healthy nutrition reestablished, the battle may be regarded as won, although it can never be assumed that a return of the habit will not occur, even when perfect recovery appears to have been secured.

HENRY H. RUSBY.

**Coccidiidia.**—An order of cell-infesting *Sporozoa*, in which reproduction is usually by schizogony and by sporogony, thus giving a life cycle with an alternation of asexual and sexual generations. After fertilization the oosphere forms sporoblasts, which may or may not be covered by a sporocyst membrane, and which may each become transformed into one or several sporozoites. See *Protozoa*.

A. S. P.

**Coccidioides.**—A genus of *Sporozoa*, family *Tetrasporocystidæ*. One species, C. *immitis*, has sometimes been found as a parasite in the human skin where it produces lesions resembling those caused by tuberculosis. See *Protozoa*. A. S. P.

**Coccidium.**—Eimeria, a genus of sporozoans in which the dizoic spores are spherical or oval. Many species are almost entirely limited to vertebrate hosts, and are found in nearly all orders. *C. cuniculi* is found in the human liver, and *C. perforans* and *C. bigeminum* frequent the intestine. See *Protozoa*.

A. S. P.

**Cocculus Indicus.**—*Fish berries, Fisher's berry, Indian berry or cockle, Levant nut.* The fruit of *Anamirta paniculata* Colebrooke (Fam. *Menispermaceæ*), a climbing plant of the East Indies, where it is largely employed for poisoning fish, and also as a parasiticide. Although a ten per cent. tincture is still somewhat employed in the United States for the latter purpose, like tincture of larkspur and stavesacre, the drug has mostly gone out of use except for the extraction of picrotoxin, its active constituent, which title should be consulted for its properties and medicinal uses. The berry is shaped somewhat like a kidney, and is about the size of a small marble. It consists of a light yellow seed of excessive bitterness, covered with a woody shell. The external coat is of a dark-brownish color.

Besides picrotoxin, it contains two inert constituents, *menispermine* and *paramenispermine*, and some saponin, to which its action on fishes is partly due.

H. H. RUSBY.

**Coccus.**—A genus of aphids or plant lice, family *Coccidæ*. The manna mentioned in the book of Exodus is pretty certainly the honey-dew secreted by *Coccus* (now *Glossyparin*) *mannifera*. The source of cochineal dye is an insect of this genus, *C. cacti*, found in America. A. S. P.

**Coccus.**—A spherical bacterium belonging to the order *Coccaceæ* (*q.v.*). See also *Micrococcus, Planococcus, Staphylococcus*, and *Streptococcus*.

**Coccus.**—COCHINEAL. The dried female insect *Pseudococcus cacti* (L). Burmeister (U. S. P.).

The cochineal insect is a native of Mexico and Central America, where it abounds as a parasite upon several genera of *Cacti*, especially the Opuntias. It is also found, probably native, in the West Indies. For commercial purposes, however, it has long been bred and raised upon *Nopalea cochinillifer* (L.) Lyons, *Opuntia tuña* (L.) Mill, and other species of Opuntia which are cultivated in plantations for the purpose. The pregnant females, about 200 times as numerous as the males, placed upon the plants, deposit numerous progeny, which feed and live there. These when fully grown (and pregnant) are collected, killed by heat, and dried. This insect, together with its foster plants, has been introduced into the West Indies, East Indies, Java, Southern Europe, and Africa.

DESCRIPTION.—The dried cochineal is described as follows: About one-fifth of an inch (5 mm.) long; of a purplish-gray or purplish-black color; nearly hemispherical; somewhat oblong and angular in outline; flat or concave beneath; convex above; transversely wrinkled; easily pulverizable, yielding a dark-red powder. Odor, faint; taste, slightly bitterish. It contains a red coloring matter, soluble in water, alcohol, or water of ammonia; slightly soluble in ether, insoluble in fixed and volatile oils. On macerating cochineal in water, the insect swells up, but no insoluble powder should be separated. It should yield not more than six per cent. of ash. There are two forms of commercial cochineal, known respectively as "silver grain" and "black grain," in reference to their superficial color.

Cochineal, being an expensive article, is subject to much adulteration; crude foreign substance, like stones, starch, tapioca, etc., and insoluble and heavy earths caused to adhere, are easily detected. The most difficult to recognize is the substitution of partially exhausted, for fresh insects; this can be detected only by a sort of assay for the coloring powder left in them.

The wild *Cocci* are collected in Mexico and elsewhere to supply an inferior grade of cochineal. Be-

sides *Coccus ilicis* Fabricius (Kermes) is a larger species, living upon a species of oak (*Quercus coccifera* Linn.). It is collected and dried in Southeastern Europe, and has constituents similar to those of *C. cacti*, but the color is inferior and less in quantity.

Composition.—Good Honduras cochineal contains, according to Hagar, six per cent. of *moisture*, from fifteen to eighteen of *fat*, from forty to forty-five of *carminic acid*, from three and a half to five of *ash*, and from seven to eleven of insoluble residue. Of these the only one of use is the carminic acid or coloring matter, a brilliant red powder, soluble in water and alcohol, but insoluble in dilute acids. It is the basis of carmine, and the different pink, purple, and other beautiful *lakes* used in painting and dyeing.

Cochineal has no medicinal value whatever, and is wholly consumed at present in the manufacture of dyes and paints. In pharmacy and confectionery it is frequently used for its color.

H. H. Rusby.

**Coccygodynia,** sometimes written coccydynia, is a painful affection of the coccyx, or of the parts in intimate relation with that bone.

It is probable that the term, which possesses the negative merit of conveying no erroneous impression concerning the pathology of the disorder, embraces several distinct diseases, some of which may be simply neuralgic; some, possibly, rheumatic; some only sympathetic; while others are certainly due to organic degeneration of the bony structure itself, or to fracture or dislocation of the bone; but, as the name implies, it matters not what may be the underlying cause, pain in the region of the coccyx is the symptom that calls into exercise the resources of our art.

The affection is more common in women than in men, and is most frequently encountered in women who have borne children, though it is by no means confined to them. It may continue indefinitely, if let alone, and the pain is sometimes very severe. The pain is provoked by pressure, by any movement of the coccyx or by contractions of the muscles attached to the bone. Sitting, and especially rising from the sitting posture, ascending stairs, walking, defecation, and even micturition in some cases, occasion paroxysms of intense suffering.

The principal causes of coccygodynia are direct violence to the coccyx, injuries inflicted during parturition, osseous degeneration, uterine, ovarian, or rectal disease, the influence of cold and, perhaps, of certain toxic agents. The *diagnosis* does not involve difficulty. A thorough physical examination will always remove any obscurity and enable the surgeon to detect, by means of bimanual manipulation with one finger in the rectum, any displacement of the bone and to distinguish between this affection and painful hemorrhoids, anal fissure, foreign bodies within the rectum, or any other pelvic disorder with which the symptoms may be associated.

A favorable *prognosis* may usually be given and, while the attacks are sometimes intractable, unless the pain should be dependent upon incurable disease elsewhere, with proper treatment, complete relief can generally be promised.

The *treatment*, of course, should be adapted to existing conditions. If, upon investigation, the affection is found to result from uterine, ovarian, or rectal disease, curative measures should be addressed to the primary disorder. In the absence of any such exciting cause, or of any displacement or appreciable disease of the bone, the remedies appropriate in neuralgia or in rheumatism may be resorted to with a fair prospect of success. Among the most potent of these are opium, quinine, arsenic, salicylate of sodium, aspirin, blisters, and electricity, and such general medication and such management as the condition of the patient may require.

In the event of failure after a faithful trial of this plan, surgical intervention should be confidently advised. Two procedures are available. One consists in the isolation of the coccyx from the surrounding tissues, by means of a tenotomy knife; the other, first practised by Dr. J. C. Nott, of Mobile, in the removal of the coccyx entire, or of the lower part of the bone.

In the great majority of cases, the thorough division of the muscular and tendinous structures surrounding the coccyx will suffice, though occasionally the extirpation or the enucleation of the bone, or a portion of it, will be found necessary to effect a permanent cure. The complete excision of the bone is followed by no lasting inconvenience, and many surgeons would prefer to do the more radical operation at once, rather than incur the risk of failure by doing only a little less, and thereby possibly subjecting the patient to the ordeal of a second operation.

The operation is made by an incision over the coccyx. All attachments to the borders and to the apex are severed close to the bone by blunt scissors. The apex being thus freed, the bone is drawn strongly backward and attachments to the anterior surface are divided. Disarticulation from the sacrum is then accomplished and, after arrest of all hemorrhage, the wound is closed. On account of the depth and size of the cavity, accurate coaptation by tiers of catgut sutures is recommended.

A modification of this operation has been suggested, in which the bone, through an incision in the skin, is ground away to any desired extent by means of a "burr" attached to a dental engine, leaving the periosteum upon the anterior surface, with all of its attachments, intact.

In one case which has come to the attention of the writer—a case reported by Dr. Floyd W. McRae of Atlanta—relief was not obtained by the ablation of the coccyx entire, but was secured only by the subsequent removal of the sacral bursa and of Luschka's gland, both of which were enlarged.

James B. Baird.

**Cochlearia.**—Horseradish, Armoracia. The root of *Roripa armoracia* (L.) Hitchcock (*Cochlearia Armoracia* L., *Nasturtium armoracia* Fries., fam. *Cruciferæ*). As a drug, the fresh root is always understood, and is official in the British Pharmacopœia as *Armoraciæ Radix*. The fresh leaves and herb are official in Germany and France. This well-known plant is a native of eastern and northern Europe, but it has been cultivated so long in other parts of the world that it occurs in a half wild state in many temperate countries. Its truly wild form is not known with certainty, and it does not readily perfect its seeds; but its roots are very tenacious of life, and make it, in localities favorable to its growth, difficult to eradicate.

Horseradish root is from one to three centimeters or more ($\frac{1}{2}$ to $1\frac{1}{2}$ in.) in diameter, and from 0.5 to 1 meter or more long; it is in cylindrical or slightly tapering pieces, with a large annulated and sometimes branched crown, generally broken in digging while still thick, twenty or thirty centimeters from the top, but sometimes much longer and then dividing into three or four long, tapering branches, or else arising from a thick horizontal axis nearly or quite as large as the vertical one. Other pieces are of the smaller branches, or of the sucker-like horizontal portion. It is brownish yellow outside and white within, rather too hard to be easily cut with a table-knife, but soft enough to be rapidly rasped or grated. When cut or grated, a pungent, peculiar odor is developed, which disappears upon drying or by heat; taste sharp and peppery, also disappearing with age and desiccation. Horseradish root and aconite root have more than once been stupidly confounded with each other, even with fatal

result. They have no resemblance whatever excepting their pungent taste. (See *Aconite.*)

The deadly poke-root has also been fatally mistaken for horseradish.

Composition.—The root appears to contain *sinigrin* (*myronate of potassium*) and a ferment, *myrosin* (?), capable of forming with the sinigrin an oil identical with that of mustard, viz., isosulphocyanide of allyl, of which the yield is about 0.05 per cent. The odor and taste of this oil are not developed until the root

Fig. 1444.—Horseradish Plant and Root.

has been crushed or grated, or treated with water. By these means these substances, which are prevented from reacting upon each other in the whole or dry tissues, are brought together. If the root is extracted with alcohol, or if it is dried, no oil is obtained; but it can then even be produced by adding the ferment of white mustard and water. The composition is thus essentially that of black mustard. The leaves also contain a sulphureted oil said to be milder than, and not identical with, that of mustard.

Action and Use.—Essentially that of mustard, to which the reader is referred. Locally it is rubefacient, and even vesicant; internally, an aromatic and stomachic; in concentrated form, an irritant. Its long-continued use as a condiment and flavor is justified by these properties. In former times it was used in scurvy, for which it is valuable, and for gout, rheumatism, asthma, etc., for which it is useless.

Administration.—Horseradish is rarely used as a medicine in this country, but if desired as an aromatic the British compound spirit offers it in an acceptable form: Horseradish root, scraped, twenty ounces; bitter orange-peel, twenty ounces; nutmeg, one-half ounce; proof spirit, one gallon; water, three pints. Mix and distil a gallon. Dose, one to two fluidrams.

W. P. Bolles.

**Cochran, Jerome.**—Born in Moscow, Tennessee, of Scotch parentage, on December 4, 1831. Most of his early life was spent in Marshall County, Mississippi. He received the degree of Doctor of Medicine first from the Botanic Medical College of Memphis, in 1857, and then afterward (1861) from the Medical Department of the University of Nashville. He was appointed a Surgeon in the Confederate Army in 1862, and served in this capacity until the end of the war. He then settled in Mobile, Alabama, and soon built up a flourishing practice. From 1868 to 1873 he was Professor of Chemistry in the Medical College of Alabama at Mobile, and afterward (until 1877) he held the Chair of Public Hygiene and Medical Jurisprudence in the same institution. In 1870, owing to poor health, he was obliged to give up private practice; and from that time onward he devoted himself actively to public hygiene and the bettering of legislation in Alabama in regard to the supervision of the public health and the regulation of the practice of medicine. "He was at various times between 1870 and 1880 Health Officer of the city of Mobile, Quarantine Physician in Mobile Bay, and County Physician for Mobile County. In 1879 he was a member of the Board of Experts appointed by Congress to confer with the congressional committees on epidemic diseases; and he wrote all of the propositions on the origin, cause, and distribution of yellow fever, which received the sanction of the board." (Stone: Biography of Eminent American Physicians and Surgeons.) Dr. Cochran died August 17, 1896.

The following list comprises a few of the more important published writings of the late Dr. Cochran: "History of the Yellow Fever Epidemic of 1873"; "History of the Smallpox Epidemic of 1874—1875 in the City of Mobile," 1875; "Yellow Fever in Relation to its Cause," 1877; "Theory and Practice of Quarantine," 1879; and "Treatment of Yellow Fever," in Hare's System of Therapeutics, 1891.

A. H. B.

**Cocillana** *N. F.*—The bark of *Guarea rusbyi* (Britton) Rusby (fam. *Meliaceæ*), a good-sized tree. The writer, in 1886, found this bark in use among the Indians of Bolivia as an emetic and purgative, and recognized by them as a fatal poison in overdoses, the symptoms being those of poisoning by ipecac, though with rather more irritation of the intestine. Its medicinal action is also in general like that of ipecac. It contains a little tannin, two resins, and the alkaloid *rusbyine* (Eccles). The two latter are active and overcome the effect of the tannin, producing a laxative effect. As an expectorant, cocillana acts within half an hour, stimulating the secretion of the bronchial mucous membrane and producing a free flow of mucus; this continues for some hours, and is followed by diminished activity of the glands. It has very little action on the skin. It has proved of greatest service in chronic and subacute bronchitis when the secretion is scanty and tenacious. In such cases, it liquefies the secretion and stimulates expectoration. The fluid extract, in doses of ♏ x. to xx. every three or four hours, seems to be the most serviceable means of securing its effects. The compound preparations now so extensively used do not contain enough of it fairly to represent its properties, and should be replaced by the fluid extract or a ten per cent. tincture. In the early stages of acute inflammation it should not be given. In patients with bronchorrhea and in the aged

with profuse secretion, it is not advised, as it does not stimulate the respiratory organs, and might produce too free secretion within the tubes. In phthisis it has to be used with caution on account of its irritant action upon the digestive tract, and the danger of producing inflammatory foci in the lungs.

HENRY H. RUSBY.

**Cockroach.**—Croton Bug. Insects belonging to the family *Blattidæ*. The have biting mouth parts; the wings are variable and are often absent. Most species live under stumps and stones but several species are commonly found in human dwellings. They are not only undesirable on account of the damage they do in feeding, but are also believed to help in spreading certain diseases. See *Insects, Poisonous*. A. S. P.

**Cocoa Butter.**—See *Cacao, Butter of*.

**Coconut, Oil of.**—*Oleum Cocos*. The fat obtained from the albumin of the seed of *Cocos nucifera* (L.) (fam. *Palmaceæ*). This magnificent palm, a native, perhaps, of tropical Asia and many islands of the Pacific and Indian Oceans, is cultivated in all warm countries for its edible seeds and numerous useful products. Its well-known fruit and seed are among the largest in the world. Several methods are employed in separating the oil, and give rise to some diversity of appearance in the product. That obtained by cold expression is softer, and melts easier than the oils obtained by heat. The latter also vary according to the degree of heat and the method used. Sometimes the pulp is simply warmed and then expressed as above, at other times the oil is boiled out as lard is in the country. The yield is about fifty per cent. The oil varies in consistence from that of hard lard or butter, to that of petroleum, in the summer, and melts between 60° and 80° F. It is greenish-white or creamy-white in color, and has a lard-like odor, with, in most specimens a certain degree of rancidity. Taste, when fresh, not disagreeable. It is a rather complicated substance, and contains free and combined fatty acids, both fixed and volatile. Among the principal glycerides are those of *palmitic, caprylic, myristic*, and *lauric acids*, also those of *stearic* and *caprinic acids*, and others.

In the countries where it is produced, coconut oil is used for all the every-day uses of such fats—food, fuel, light, soap, etc. In temperate climates it is not likely to displace the olive, cotton-seed, almond, and many other oils like them, with which those countries abound. It is, however, abundant and cheap, and when good, not disagreeable—and well adapted to fill the place of lard and other animal fats in the preparation of ointments and cerates. It has been given as a substitute for cod-liver oil, but with no particular advantage. It is very largely used in soaps. A butter, to be distinguished from Cacao butter, is made from this oil, which possesses the merit often during hot climates without becoming rancid, and this has been recommended for military and naval uses. Distinct tenicidal properties are recognized in the domestic uses of coconut oil, and large doses (℥ ij. to iv.) have proven efficient in intractable cases of tapeworm. A properly made coconut oil soap has no equal among the many varieties of soap now in use.

HENRY H. RUSBY.

**Codeina.**—CODEINE ($C_{17}H_{17}[OCH_3][OH]NO+H_2O$). This alkaloid, which is chemically *methyl morphine*, is obtained from opium to the extent of about one-fifth to two per cent. Its solubility in water, about gr. vi. to the ounce, as well as in alcohol, is noteworthy. It is thus described: White, or nearly translucent, orthorhombic prisms, or octahedral crystals, odorless, having a faintly bitter taste, and slightly efflorescent in warm air. Soluble, at 15° C. (59° F.), in 80 parts of water and in 3 parts of alcohol. In boiling water codeine melts into oily drops which dissolve in 17 parts of the water. It is very soluble in boiling alcohol; also soluble in 30 parts of ether and in 2 parts of chloroform. At 100° C. (212° F.) codeine loses its water of crystallization (5.67 per cent.); at 155° C. (311° F.) it melts, forming a colorless liquid; and, when ignited, it is consumed without leaving a residue. Codeine is neutral to litmus paper. Codeine is dissolved by cold concentrated sulphuric acid (free from nitrose) without producing a color. If about 2 c.c. of this solution be poured into a small porcelain capsule, and 1 drop of highly diluted nitric acid (made by adding 1 drop of nitric acid to 100 c.c. of water) added, a bluish or blue tint will be developed. Another portion of this solution, of about 2 c.c., gently warmed, and mixed with 1 drop of a mixture of 1 volume of ferric chloride T. S. and 19 volumes of water, likewise assumes a bluish or blue tint (difference from *morphine*). On adding to 5 c.c. of an aqueous solution of codeine (1 to 100) 10 drops of bromine water, and shaking so as to redissolve the precipitate formed, the liquid will gradually develop a light claret-red tint. This tint may be developed at once by the addition of ammonia water. On sprinkling 0.05 gram of codeine upon 2 c.c. of nitric acid (specific gravity 1.200), the crystals will turn red, but the acid, even when warmed, will acquire only a yellow color (difference from and absence of *morphine*). Commercial codeine is very prone to contain morphine as an impurity. Both the phosphate and the sulphate are official and are largely employed. The phosphate is very soluble in water, but the sulphate requires 40 parts and the hydrochlorate requires 20 parts.

The properties are in general similar to those of morphine, but it cannot subdue pain. Light irritations, however, yield to it. It depresses the cerebral functions, and if there be not much pain or other preventive cause, induces sleep. This is followed by increased excitability. It therefore appears that, just opposite to morphine, its primary action is depressant, its secondary stimulant, a fact which is commonly true of methyl compounds as compared with the substances not so combined. It thus follows that the secondary effects are secured more promptly and strongly with increase of dosage, and for an anodyne the dose must be kept down. The most common use of codeine is as a respiratory sedative. It does nothing to cure the condition but relieves the disturbance, reduces the cough, and thus permits sleep. It will also reduce the amount of sugar in the urine. It has been used to favor recovery from the morphine habit. The dose is gr. ss. to iss. (0.03 to 0.1). For hypodermic injection the dose is about half as great. HENRY H. RUSBY.

**Cod-liver Oil.**—OLEUM MORRHUÆ. *Oleum Jecoris Aselli*. "A fixed oil obtained from the fresh livers of *Gadus morrhua L.*, and of other species of *Gadus*" (U. S. P.). The similar oils from the pollock, hake, and haddock have also been much used, but are not now officially recognized. The English and German Pharmacopœias unite in requiring the oil to be expressed without much heat. The United States does not limit the heat, but the requirements of the market here effectually exclude oils in any way injured in extraction. The British Pharmacopœia requires that the solid fat be filtered out at about 23 ° F.

The codfish is too well known to require description. It is very widely distributed and abundant, inhabiting the temperate and colder parts of both the Atlantic and the Pacific Oceans.

Cod-liver oil is prepared in several ways, according to the character of the fisheries and the use to which it is to be put. If the fishermen are far from shore, as

on the Banks, where the boats remain out perhaps for several weeks, the livers are thrown, as the fish are cleaned, into barrels, where they lie until putrefaction begins, and the oil escaping from the decomposing cells rises to the top. This is then drawn off. Upon returning to the shore, the remaining pulp is boiled and the rest of the oil strained out. Such products are dark in color, offensive-smelling, and unfit for medicine. The pale, sweet oils are made by fishermen who catch near shore, and every day or two land with their fish; they separate the oil at once from the fresh and clean livers. The common way is simply to scald the livers in water until the tissues become disintegrated, when the mass is strained through cloths, the water and oil finally separating from each other upon standing. The best method is to heat the livers in a vat or barrel by means of injected steam until they become softened, and then strain them and allow the oil to separate as above. Most of the fine oil used in this country is prepared in this way during the winter months, and then has also a portion of its stearin, etc., removed by freezing and expression. Some of our fine oil is manufactured on the New England coast; that of Europe, in Norway, Scotland, and England. The better grades of Norwegian oil are now very extensively imported for medicinal use here. The best is the Loffoten.

Cod-liver oil has had some reputation as a medicine for a century or more, but its extensive and most important use in phthisis is less than half as old.

The quality of oil suitable for dispensing is a pale yellow liquid of faint fishy odor, and a peculiar, at first not very marked, but finally disagreeable, slightly acrid taste. It does not dissolve in alcohol, but, like all fats, is readily soluble in ether. Its specific gravity is about 0.922. "If one drop of the oil be dissolved in twenty drops of chloroform, and the solution shaken with one drop of sulphuric acid, it will acquire a violet-red tint, rapidly changing to rose-red and brownish-yellow (U. S. P.). In addition to the above test, and others, a cultivated taste and smell are necessary to judge of the quality, or even genuineness, of the drug.

Composition.—Although a complex mixture, it is not known how far its value depends upon its complexity; certain it is that the modern clear and comparatively agreeable oils contain less of the unusual ingredients than the older ones, and that some of these ingredients, at least, were cadaveric products of decomposition of the livers, or empyreumatic decompositions brought about by the method of manufacture. These clear and light oils are more efficient as medicines, as they certainly are less disgusting, and can be taken by numerous persons who could not endure the others.

The very different action of cod-liver oil from that of other animal fats consisting of olein, palmitin, and stearin has recently been explained by the announcement that its constituents are chiefly therapin and jecolein, fatty substances very different from those above named. On the other hand, assuming it to have the usual composition, the most extensive efforts have been made to discover in it something in the nature of an active constituent. Iodine, bromine, phosphorus, cholesterin, and bile acids have all in turn been credited with the peculiar properties of the oil, but these theories have been successively abandoned. Free acids are less in amount in the better oils, and the same is true of the several alkaloids which have been discovered, especially trimethylamine, aselline, and morrhuine. This question is of great importance, as it determines our ability or inability to secure the effects of the oil from extractive preparations. It may, however, be truthfully affirmed that this has not been found possible. The body of the oil must be assimilated in order to get its benefits, and the above theory as to its fatty substances being *sui generis* is the only one which presents elements of probability.

Action and Use.—This is the most readily absorbed and assimilated of oils. A loop of intestine containing it, compared with another containing another oil, is said to show an appreciable gain over the other in absorption. It is natural, therefore, that, added to other food, it should increase nutrition and the accumulation of fat. This quality is sufficient to explain its usefulness in the treatment of cases of simple emaciation, from bad nutrition, in chronic and wasting diseases, at the end of fevers, etc. So far, it can hardly be considered a medicine, but only a particularly useful form of non-nitrogenous food. It is emulsified and absorbed exactly as other oils are, and undoubtedly becomes in the same way a part of the body tissues. In this view, other oils should have the same effect according to their assimilability, and suitable doses of olive, linseed, and lard oils should be equally as good, and cream, from its state of emulsion, even better. Experience has not, however, confirmed their equality. The most important uses of cod-liver oil, moreover, are observed in a series of cases whose pathology is as obscure as the action of the remedy—such as the "scrofulous" diseases, whether glandular or ulcerative, chronic rheumatism, etc. It must in these cases act in some gentle and peculiar way upon the pathological processes, tending to return them to normal physiological ones, and in this respect is to be classed in the heterogeneous number of medicines called alteratives. Its uses have been mostly noticed in the preceding sentence but may be recapitulated a little more in detail. It is given, more than in any other disease, in phthisis pulmonalis. The long, wasting course of this complaint calls very distinctly for remedies that will prevent waste on the one hand, and promote nutrition on the other. Alcohol and cod-liver oil may be regarded as types of these two therapeutic agents, and experience has long ago shown them to be two of the most generally useful things that can be given. Neither is a specific, neither appears in the slightest degree to change the character of the poison lying at the root of the complaint, but both retard the loss of flesh and strength, each in its peculiar way. The oil is often given alone in the early stages of the disease, and generally with advantage, as alcohol in small doses more readily loses its effect. It is also frequently combined with malt extracts, the hypophosphites, iron, iodine, and other alteratives or aids to nutrition. Besides the general action, the oil has an undoubted favorable effect upon the chronic bronchitis and catarrhal pneumonia present, and it is therefore of value in the cough of consumption. It is also of great service in subacute and chronic idiopathic bronchitis ("colds in the chest"). In the persisting colds of infants and the aged, with a good deal of weakness, it has no equal. In chronic catarrh of various mucous membranes, ear, nose, vagina, urethra, etc., especially if attended with, or depending upon, debility, it is sometimes useful. In hip disease, and similar degenerations of other joints; in glandular abscesses, in chronic ulcers; in short, wherever there are waste, emaciation, and thinness of blood, it is to be tried. A peculiar method of its employment in the fisheries is in half-tumblerful doses, to break up an acute cold.

The great obstacles to the fullest use of cod-liver oil are its taste, which is so repugnant to many that they can scarcely take it, and its liability to disagree with the stomach, and either to produce nausea and vomiting, or, what is equally disastrous, to impair the appetite and so to more than undo all its possible benefit. The different methods of administration mentioned below sometimes overcome this, but most important is the exclusive use of the carefully prepared and nearly tasteless oils referred to above.

Administration.—The dose of the oil is ℥ iij. to ℥ i. (12.0–30.0) two or three times a day. If it can be taken clear it may be so given; the taste, even of the best, is somewhat repulsive, and becomes more so toward the last of the bottle in summer, as it rather easily becomes rancid. It is best, therefore, to purchase only a small quantity at a time, and to keep it as cool as possible. The taste may be disguised by means similar to those used with other oils (*e.g. Castor Oil, q.v.*): rinsing the mouth thoroughly with whiskey, spirit of lemon, peppermint, or some such pungent vehicle, swallowing the oil at once, and again rinsing the mouth, is as good as any of the extemporaneous means used for this purpose. The liquor, if one prefers to do so, may be spit out. Large elastic capsules containing ℥ i. to ij. (4.0–8.0) are made, but not much used, on account of their expensiveness. The following combination, when liquor is to be given with it, is a well-known favorite:

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|---|---|
| Cod-liver oil | 50 parts |
| Whiskey | 35 parts |
| Comp. tincture of lavender | 15 parts |

It must be thoroughly shaken for every dose, as the oil immediately begins to separate. The lavender is added only as a flavor, and may be omitted. All oils appear to be less offensive to children than to adults.

Another method is to mix the oil with about an equal part of one of the syrupy malt extracts; the mixture does not separate so readily as the above. Its taste is well borne by children. Then there are the numerous emulsions made and advertised everywhere. They come under one of the following classes: First, mucilage emulsions, of which the following is an example:

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|---|---|
| Cod-liver oil | 50 parts |
| Oil of wintergreen | 2 parts |
| Mucilage of tragacanth | 15 parts |
| Water of orange flowers, sufficient to make | 100 parts |

A little "knack" is required to make it well. The mucilage is the emulsifying agent, and the oil should be added to it very slowly, and *most thoroughly stirred until it is divided into invisible particles*, before the water is added. The oil of wintergreen is only a flavor, which may be varied to suit. This makes a good, permanent mixture of about the consistence and appearance of thick cream. Instead of tragacanth, mucilage of acacia, about twice the amount, or a decoction of Irish moss may be used.

Second, egg emulsions: These are made like salad dressings, by using the yolk of egg as the suspending ingredient. The following is a good one:

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|---|---|
| Cod-liver oil | 50 parts |
| Oil of sassafras | 3 parts |
| Chloroform | 2 parts |
| Glycerite of yolk of egg | 10 parts |
| Rose water, enough to make | 100 parts |

Here the oil and the egg must first be "emulsified," when the other ingredients may be added—the water last. This is a thinner liquid than the preceding.

The pancreatic emulsions are nominally made by emulsifying with pancreatin, and are theoretically the most perfect of all, but are practically attended with some difficulty; the ordinary "pancreatin" of the shops will not make a good result, and of those claimed to be so produced some are made by means of added alkalies, others by the fresh pancreas itself, and some do not even contain any cod-liver oil at all. Considerable care has to be exercised with all proprietary preparations, to see that the percentage of oil is not deficient, as the drawing out of the oil is a favorite method of rendering the preparation palatable. An ounce or two of perfectly sweet pancreas, chopped fine and mixed thoroughly with a gallon of oil, will, it is said, suffice, when the oil is filtered off and mixed with water, to emulsify it perfectly. Like the other emulsions, it can be flavored to taste. Iodine, iron, the hypophosphites, and other suitable additions can be made to all of them, but alcohol and tinctures are incompatible with the mucilaginous ones. If the patient would chew a bit of raw smoked herring before taking the oil, its taste would not be noticed.

The "wines," and similar preparations, of cod-liver oil, under whatever fanciful names, are utterly unreliable and are to be classed as unscientific.

*Morrhuol* is an alcoholic extract of the oil. Very little is yielded by fresh sweet oils, and the yield increases with the degree of putridity of the article. It is therefore to be regarded as essentially a putrefactive product, and whatever useful properties it may claim to possess, it need not be used for the effects of the oil.

Cod-liver oil is often given by inunction, with benefit, especially to marasmic babies. H. H. Rusby.

**Codrenin** is the name given to various solutions containing cocaine hydrochloride and adrenalin; some of them contain chloretone in addition. It is used as a local anesthetic and hemostatic, and is chiefly employed in dentistry and oral and nasal surgery.

R. J. E. Scott.

**Cœliohysterectomy.**—See *Cesarean Section.*

**Cœlom.**—The name cœlom (Greek κοίλωμα, a cavity) was proposed by Haeckel (1872) to designate the true body-cavities of vertebrates, that is, pleuroperitoneal cavities and their homologues in the invertebrate animals.

The true cœlom consists of one or more cavities hollowed out in the mesoderm and lined by an epithelium of mesodermal origin. That all body-cavities other than the alimentary canal are not cœlomic was first pointed out by the brothers Hertwig (1881). They showed that the perivisceral spaces in the mollusca, rotifera, and polyzoa are not cœlomic and gave to them the name of *pseudocœl*. Later Lankester, as the result of the studies of the vascular system in the mollusca and arthropoda came to the conclusion "that the system of blood-containing spaces pervading the body in Mollusca and in Arthropoda is, in reality, a distended and irregularly swollen part of the vascular system." To these spaces he gave the name *Hæmocœl*, as distinguished from the cœlom.

The phylogenetic origin of the cœlom is, according to Lankester (1900), to be sought in spaces pinched off from the endoderm to contain the reproductive glands or gonads. According to this view, the true cœlom is always primarily a *gonocœl*, and the ducts which arise in the walls of the cœlom and lead to the exterior are primarily genital ducts, although they may acquire secondarily a renal function. These ducts are thus distinguished from the true nephridia, like those of the flat worms and annelids, which arise "from single cells ultimately though not always actually traceable to ectoderm," and have primarily a renal function, but may secondarily form a connection with the genital ducts.

*The Cœlom of Vertebrates.*—The primitive cœlom, or *protocœlom*, of vertebrates may be regarded as a series of paired sacs lying on each side of the body between the ectoderm and the endoderm. From the protocœlom are derived the following spaces: the cavities of the myotomes and the *syncœlom*, or perivisceral space (Fig. 1445), and the latter is subdivided into pericardium, peritoneal cavity, pleural cavity, lesser peritoneal cavity, exocœlom, and tunicæ vaginales. Of these spaces, the cavities of myotomes and the exocœlom are purely embryonic structures. The

former may be present in all vertebrates, but disappear at a very early stage as the result of the thickening of the walls of the myotomes to form the skeletal muscles. The exocœlom is absent in holoblastic embryos, and when present, is ultimately separated from the pericardium and the pleuroperitoneal space by the infolding of the body-wall that results in the separation of the body of the embryo from the extraembryonic blastoderm. The remaining spaces are not developed in all adult vertebrates. In the fishes, the lower amphibia, and the lower reptiles, the heart is situated in the head region. In these animals, the cœlom of the adult is divided into two chambers, the pericardium and the peritoneal cavity. The former is nearly filled by the heart and the latter by the abdominal viscera. The two chambers are separated by a transverse partition called the *septum transversum*. This septum is covered on its anterior face by the epithelial lining of the pericardium and on its posterior face wholly or partly by the liver. It is penetrated by the veins that pass from the liver and from the body-wall to the heart, and by the esophagus. In most vertebrates the pericardium is a closed cavity, but in the hag fishes and the selachians the two cœlomic cavities communicate by a small opening in the septum transversum. In the hag fishes this opening is primitive, while in the selachians it is a secondary structure.

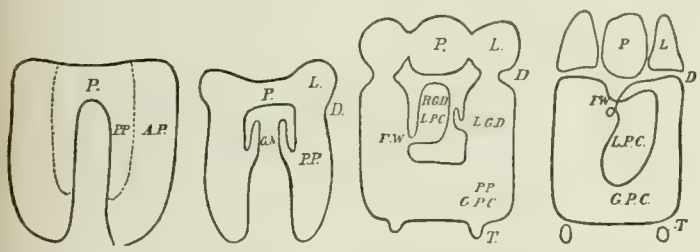


Fig. 1445.—Diagrams to Show the Development of the Cœlomic Cavity. *PP*, Pleuroperitoneal cavity; *AP*, exocœlom; *P*, pericardial cavity; *L*, pleural cavity; *GN*, recessus pneumato-entericus, right and left; *D*, position of the diaphragm; *LGD*, left recessus pneumato-entericus; *RGD*, right recessus pneumato-entericus or lesser peritoneal cavity; *FW*, foramen of Winslow; *GPC*, greater peritoneal cavity; *T*, tunica vaginalis. (From Mall.)

With the development of the neck in the higher air-breathing vertebrates, there is a shifting of the viscera backward, and many changes occur in the relative positions of the organs. In the lower vertebrates the side walls and floor of the pericardium are formed by the body-wall while its roof is the floor of the esophagus or of the pharynx. When lungs are developed, they appear dorsal to the heart, and project into forward extensions of the cœlom, the *pleural cavities* (L, Fig. 1445), which are separated by the dorsal and ventral mesenteries of the esophagus. These mesenteries form a vertical longitudinal partition, and the ventral mesentery is the only connection between the esophagus and the pericardium. The roof of the pericardium is now the *pleuropericardial membrane*.

As the lungs increase in importance, they increase in size and, in some animals, aided by the liver (*e.g.* Anura), they burrow, as it were, into the sides of the body-wall, thus pushing the pleural cavities around the sides of the pericardium. In this way the pleuropericardial membrane may be extended, until, as in the frogs, the heart appears to lie almost free in the body-cavity covered only by a thin membranous pericardium.

In the amphibia and lower reptiles, the pleural and peritoneal cavities are in free communication, but in the higher reptiles there is more or less separation, amounting to a complete division in the crocodiles. In the birds and mammals, the separation is always completed during the embryonic life. The method of separation, however, differs in each of these groups. The partition dividing the pleural from the peritoneal cavities is the *pleuroperitoneal membrane*, and this, with the septum transversum, forms the major portion of the mammalian *diaphragm*.

The dorsal portion of the *peritoneal cavity* is usually divided completely into right and left halves by a dorsal mesentery that extends from the dorsal midline to the stomach and intestine. But these two halves unite into a single abdominal cavity ventral to the intestine. At the anterior end a ventral mesentery is developed by the right and left sheets of splanchnic peritoneum becoming closely approximated ventral to the stomach and extending over and around the liver and bile duct, thus forming the lesser omentum and the coronary and falciform ligaments of the liver. At the posterior end, a ventral mesentery encloses the stalk of the allantois and the urinary bladder, when present.

The *lesser peritoneal cavity* (R.G.D., Fig. 1445) appears first in the dorsal mesentery (mesogastrium) of the stomach as a small invagination of the peritoneum on the right side extending mesially and anteriorly. By the enlargement of this invagination aided by the curvature and rotation of the stomach, the lesser peritoneal cavity crosses the median line to the left side of the body. In this way the mesogastrium is converted into a large sac, known as the great omentum and the lesser peritoneal cavity (L. P. C., Fig. 1445), enclosed within its folds, becomes the *bursa omentis*. The orifice by which the lesser and greater peritoneal cavities communicate persists as the *foramen of Winslow*.

In the mammalia, a *tunica vaginalis* appears on each side of the abdominal cavity as a small evagination of the peritoneum (T, Fig. 1445) in front of the os pubis. These cavities are present in the embryo of both sexes, but soon disappear in the female. In the male, they form the peritoneal cavities of spermatic cords and scrotal sac, into which the testes descend. By the subsequent closure of their orifices in most mammals, they become completely separated from the abdominal cavity (T, Fig. 1445).

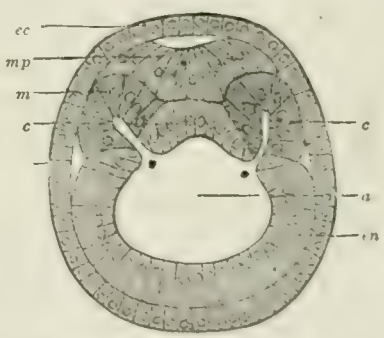


Fig. 1446.—Section of an Amphioxus Embryo with Four Segments. *a*, Archenteron; *c*, cœlom; *ch*, chorda; *ec*, ectoderm; *en*, endoderm; *m*, mesoderm; *mp*, medullary plate. *openings of the cœlomic pouches. (From Hertwig after Hatschek.)

*Development of the Cœlom.*—In its earliest stages, the development of the cœlom is but one phase in the differentiation of the mesoderm (*q.v.*), which is discussed in another article. This process differs considerably in detail in the various groups of vertebrates, but we shall probably be with the majority of the embryologists if we follow O. Hertwig (1903) in taking the mode of development of the cœlom in Amphioxus as the most primitive type.

Although this animal has been studied by a number

of observers it is still in the classical work of Hatschek (1881) that we find the foundation of our knowledge of the embryology of Amphioxus. Here the cœlom is produced by dorsolateral evaginations of the wall of the archenteron, the primitive digestive cavity of the ga trula. First, two longitudinal grooves appear, one on each side of the rudiment of the notochord. The

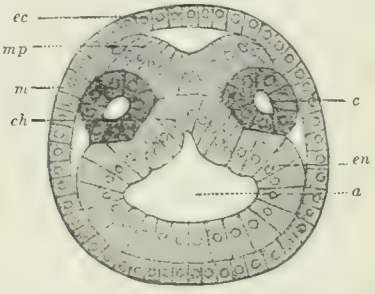


Fig. 1447.—Section of an Amphioxus Embryo with Five Segments. Lettering same as Fig. 1446. (From Hertwig after Hatschek.)

walls of these grooves are the mesodermal folds (Fig. 1446) and the cavities enclosed by them the cœlomic spaces. From the mesodermal folds, the mesodermal somites are produced by a series of transverse furrows that appear on the outer surface of the folds beginning at the anterior end. By this process and the gradual closing of the opening into the archenteron, the meso-

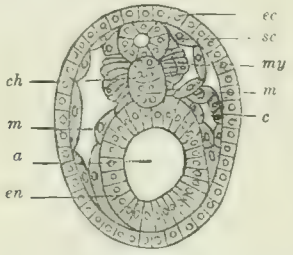


Fig. 1448.—Section of an Amphioxus Embryo with Eleven Segments. *a*, Alimentary canal; *c*, cœlom, on the right apparently divided into two cavities because the section cuts obliquely through a vertical septum; *ch*, chorda; *ec*, ectoderm; *en*, endoderm; *m*, mesoderm; *my*, myotome; *sc*, spinal cord. (From Hertwig after Hatschek.)

derm is converted into a series of paired segments (Fig. 1447) lying on each side of the medullary plate between the ectoderm and endoderm. The lumen of each one disappears for a time, but soon reappears as the segments expand and begin to grow both dorsally and ventrally, but chiefly in the latter direction, thus separating the endodermal wall of the digestive cavity from the outer covering of the body (Fig. 1448). The mesodermal somites are now a series of vesicles enclosing cœlomic cavities.

The next step in the development of the cœlom is the breaking down of the ventral portions of the partitions between the somites. In this way a continuous body cavity is formed on each side in the region corresponding to the lateral-plate mesoderm of the higher vertebrates. The dorsal portions of the segments on each side of the spinal cord and notochord remain distinct, and ultimately give rise to the striated muscles of the body.

In none of the true vertebrates is the cœlom so clearly developed by evagination from the archenteron. But in some of the lower forms, as in certain amphibia (Fig. 1449), at an early stage of development the mesoderm is not completely cut off from the archenteron and the free surface of the bordering cells forms a band extending longitudinally on each side of the notochord. There are indications of a continuity between mesodermal cells and notochordal folds on the one side, and between the former and the general endoderm on the other. Moreover, the free surface of the mesoderm may be indented by a slight groove, indicating a division of the mesoderm into two layers. Certain phases of the development of the

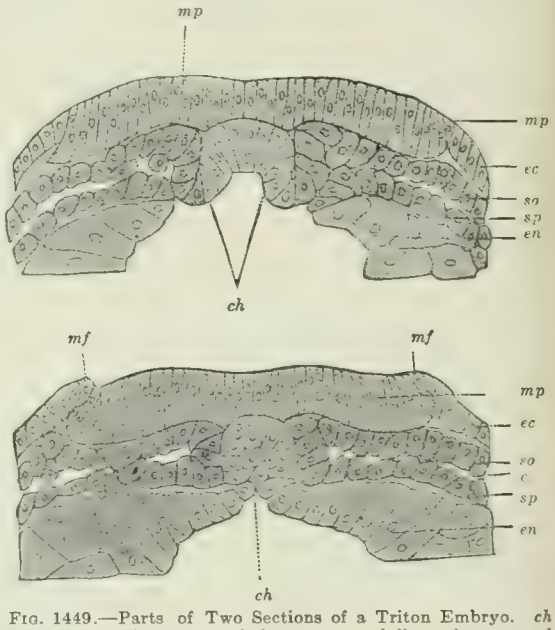


Fig. 1449.—Parts of Two Sections of a Triton Embryo. *ch* Chorda; *ec*, ectoderm; *en*, endoderm; *mp*, medullary plate; *so* and *sp*, somatic and splanchnic mesoderm. (After Hertwig.)

lampreys are even more suggestive of an origin of the mesoderm by evagination from the wall of the archenteron.

In most vertebrates, however, the mesoderm first appears as a continuous layer of cells growing from the edge of the blastopore (*q.v.*), or from the primitive streak, and spreading from the sides of the notochord (Fig. 1450). This mass of cells is soon split into an outer somatic and an inner splanchnic layer and the space thus formed between them is the primitive cœlom. Later, by the development of longitudinal and transverse furrows, the myotomes are differentiated from the lateral plates of the mesoderm (Fig. 1451) and, as in Amphioxus, their cavities, the myocœls, disappear, while their walls develop at least into the principal striated muscles of the trunk.

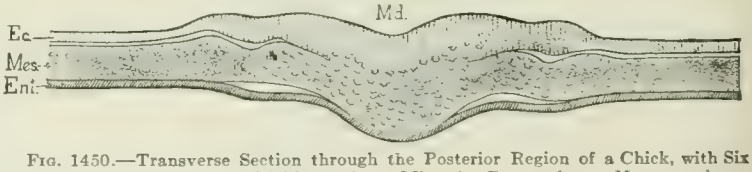


Fig. 1450.—Transverse Section through the Posterior Region of a Chick, with Six Pairs of Myotomes. (After Waldeyer, from Minot.) *Ec*, ectoderm; *Mes*, mesoderm; *Ent*, endoderm; *Md*, medullary groove.

The permanent cœlom lies wholly between the lateral plates, and consists at first of two cavities, separated by the alimentary canal and its dorsal and ventral mesenteries when they are present. The ventral mesentery soon disappears and the two cavities are thus united into a single syncœlom. Subsequent development consists in the division of the syncœlom into the secondary cavities mentioned in the previous section.

*Division of the Cœlom.*—The fundamental division of the syncœlom is into pericardium and peritoneal or pleuroperitoneal space. The development of the pericardium is ultimately connected with the development of the heart and liver. In Amphibian embryos in which the head is beginning to elongate, most of the alimentary canal is a very narrow tube with very thick endodermal walls. But in the head region the

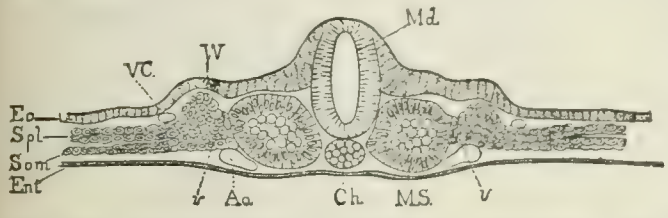


Fig. 1451.—Transverse Section of a Chick of the Second Day. (After Waldeyer, from Minot.) *Som*, Somatic mesoderm; *Spl*, splanchnic mesoderm; *Ec*, ectoderm; *Ent*, endoderm; *VC*, vein; *W*, Wolffian duct; *Md*, medullary canal; *Ao*, aorta; *Ch*, chorda; *MS*, myotome.

endodermal tube is expanded into a large cavity with walls one cell thick. This is the foregut and behind it is another endodermal pocket, the liver diverticulum, the two being separated, on the ventral side, by a low transverse ridge. From the anterior part of the lateral mesoderm on each side, a pouch grows into this ridge (Fig. 1452). As the two mesodermal pouches approach each other, they enclose between them cells

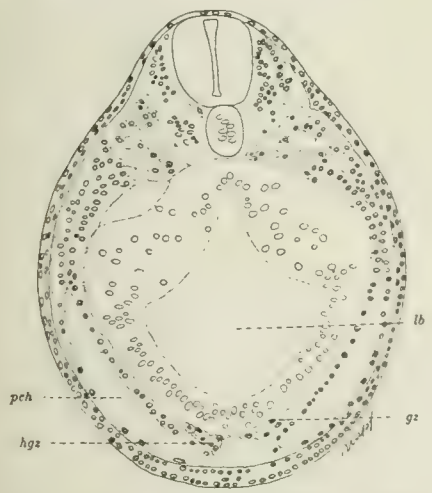


Fig. 1452.—Section of an Embryo of Triton with Sixteen Segments. *gz*, Angioblast; *hgz*, cardiac angioblast; *lb*, liver diverticulum; *pch*, pericardium. (After Mollier.)

(Fig. 1453), that soon arrange themselves into a tube to form the endothelium of the heart and continue posteriorly around the liver as the omphalomesenteric veins. (See *Blood-vascular System, Origin of.*) From those parts of the walls of the mesodermal pouches that come into contact with the cardiac endothelium are developed the muscular and serous coats of the heart, while the cavities of the pouches persist as the pericardium. As development proceeds the walls of the two pouches meet at first on the ventral side and later on the dorsal side of the heart, thus forming the *mesocardia* which, with the heart, divides the pericardium into two cavities. But soon the ventral mesocardium disappears, followed later by the dorsal one. Thus the pericardium comes to be a single cavity to the walls of which the heart is attached in front by the truncus arteriosus and behind by the sinus venosus. At first the posterior wall of the pericardium is in immediate contact with the endodermal cells of the liver. Subsequently a mass of connective tissue develops between the pericardial epithelium and the liver. This is the *septum transversum*.

In the reptiles and birds the development of the cœlomic spaces is modified by the pressure of a large amount of yolk in the egg. At the animal pole of the egg the blastoderm (*q.v.*), consisting of the three germ-layers, grows over the yolk like a cap. The formation of the cœlom begins by the appearance in the mesoderm of a number of cavities which flow together and separate the somatic and splanchnic layers, except at the edges of the mesoderm where they are continuous. On each side of the notochord, the myotomes are differentiated, as in the amphibia. Of the lateral mesodermal plates the outer one with the ectoderm forms a two-layered membrane, the somatopleure, and likewise, the inner mesodermal plate with the endoderm forms the splanchnopleure. The space between the two forms the permanent body cavities and the exocœlom. The embryo is formed by the folding of the blastoderm. This begins at the anterior end in an area free from mesoderm. Here the blastoderm, consisting of ectoderm and endoderm, grows unequally, and is therefore thrown into two folds—an outer one,

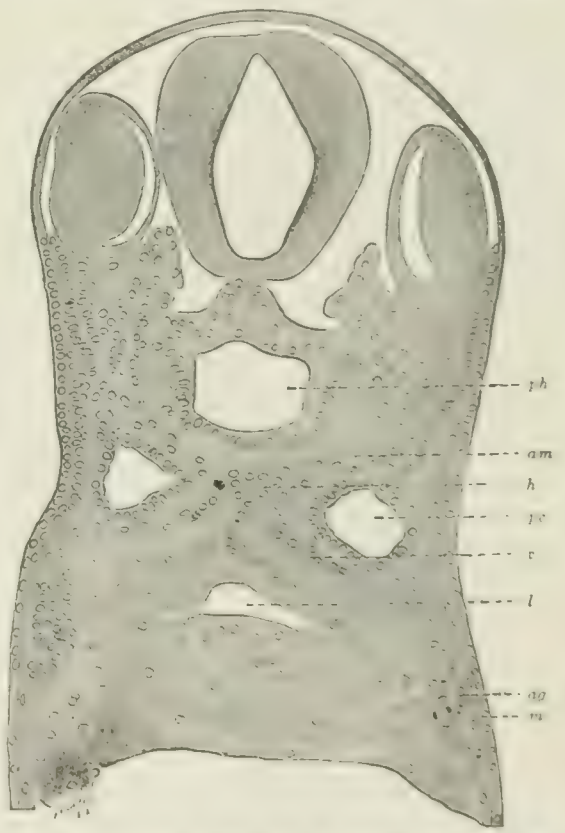


Fig. 1453.—Frontal Section of an Embryo of Triton with Nineteen Segments. *aa*, Anterior branch of ventral band of angioblast; *am*, mandibular artery; *h*, heart; *l*, liver; *m*, mesoderm; *pc*, pericardium; *ph*, pharynx; *v*, omphalomesenteric vein. (After Mollier.)

extending forward, the *head process*, and an inner one extending backward, the *head fold*. The endodermal cavity in the head process is the foregut, which opens freely into the subgerminal space behind the head fold.

The orifice of communication between the two is known as the *anterior intestinal portal.*

On each side of the head process, the mesodermal wings extend forward around the proamnion (*q.v.*) and the cœlomic spaces within them become inflated, forming two *amnio-cardiac vesicles* (*c*, Fig. 1454). From each of these a pouch pushes in between the

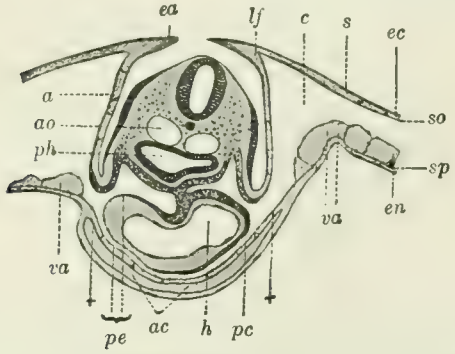


Fig. 1454.—Transverse Section of the Embryo of an Albatross. *a*, Amnion; *ao*, aorta; *c*, amnio-cardiac vesicle; *h*, heart; *pc*, pericardium; *ph*, pharynx; *so*, somatopleure; *sp*, splanchnopleure. (After Schauinsland.)

ectoderm and endoderm of the head fold until the two pouches meet beneath the foregut and clasp between them the endothelial tube of the heart, which is somewhat more advanced than in the corresponding stage in the amphibia. The two pouches form the pericardium (*p.c.*, Fig. 1454) the two halves of which subsequently come into communication by the dissolution of the mesocardia.

By the gradual extension backward of the head fold and the lateral folds of the somatopleure, the pericardium first and then the pleuroperitoneal cavity are separated from the exocœlom. But for some time after the pericardium has lost its direct communication with the exocœlom, it still communicates with the pleuroperitoneal space and the latter is open into the exocœlom (Fig. 1455).

At this stage, the posterior wall of the pericardium is the wall of the anterior intestinal portal. In this, the right and left omphalomesenteric veins unite to form the sinus venosus, which receives also the ducts of Cuvier from the body-wall. The tissue surrounding the ducts of Cuvier forms what are known as the *lateral mesocardia.* They connect the sides of the pericardium with the heart, and on each side divide the opening between the pericardium and the peritoneal space into a *dorsal* and a *ventral parietal recess.* The liver has its beginnings in two diverticula which extend anteriorly into the endoderm of the wall of the anterior intestinal portal, one of them lying above the other below the fork of the omphalomesenteric veins.

As the anterior intestinal portal is carried further backward by the continual infolding of the splanchnopleure, the liver comes to lie in the ventral mesentery of the stomach and intestine. The ventral parietal recesses are closed by the formation of the septum transversum. This consists of three parts: (1) a median mass, including the ventral mesentery, liver, and sinus venosus, (2) the lateral mesocardia, and (3) a lateral fold from the body-wall which grows inward and, joining the other two, completes the septum.

Until the end of the third day of incubation the heart of the chick embryo lies directly under the pharynx. Then begins the formation of the neck with the elongation of the esophagus and the shifting backward of the heart, which takes place rapidly between the third and sixth days (Lillie, 1908). Thus the heart comes to lie beneath the esophagus and, as a result of this shifting, the lateral mesocardia are drawn out obliquely over the heart. In the meantime the lung buds have developed and the bronchi

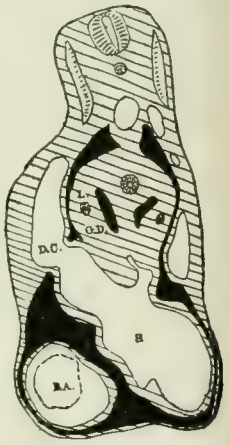


Fig. 1456.—Section through the Region of the Heart of a Chick of Seventy Hours. (× 35 times.) The section strikes the oral end of the recessus pneumato-entericus *G.D.*, and the tips of the pulmonary buds, *L.* A few sections deeper the recessus pneumato-entericus communicates with the pleuroperitoneal cavity. *H.*, heart; *D.C.*, ductus Cuvieri; *B.A.*, bulbus aortæ. (From Mall.)

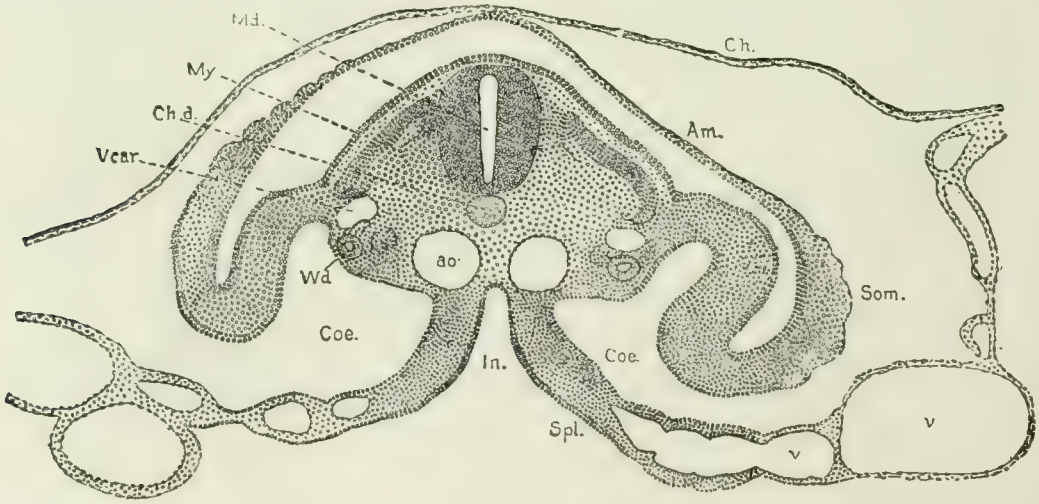


Fig. 1455.—Section through the Body of a Chick of the Third Day. (After Minot.) *Ch*, Chorion; *Am*, amnion; *Som*, somatopleure; *v*, blood-vessels; *Coe*, cœlom; *Spl*, splanchnopleure; *In*, intestine; *ao*, aorta; *Wd*, Wolffian duct, *Vcar*, vena cardinalis; *Chd*, chorda dorsalis; *My*, myotome; *Md*, medullary canal.

project laterally from the esophagus. By the fusion of the lateral mesocardia with the bronchi, the pleuropericardial membrane is formed and the pericardium is finally separated from the dorsal parietal recesses, which now contain the lungs and become part of the *pleural sacs*. The manner in which the pericardial membrane becomes independent of the body-wall has been indicated in a previous paragraph.

In most reptiles, the pleural cavities remain in more or less open communication with the peritoneal cavity. But in the birds they become completely closed. This closure is effected by the fusion of the *accessory mesenteries* with the body-wall. The endodermal

Fig. 1457.—Section through the Pleural Cavities and Adjacent Organs of a Chick Embryo Incubated Eight Days. *A*, Aorta; *as*, air sac; *l*, liver; *lg*, lung; *mf*, mesonephric fold; *mg*, stomach; *e*, esophagus. (After Hochstetter, 1901.)

lung buds extend into the accessory mesenteries, which are sheets of tissue that at first extend vertically from the sides of the esophagus to the septum transversum and the liver, and enclose the *pneumatoenteric recesses*. The latter are a pair of cœlomic pockets. They open into the peritoneal space on each side at the level of the stomach and extend forward between the esophagus and lung buds where they end blindly (Fig. 1456). As the liver broadens, the attachments of the accessory mesenteries are carried laterally until they touch the body-wall (Fig. 1457) with which they fuse and then lose their connection with the liver. Thus are

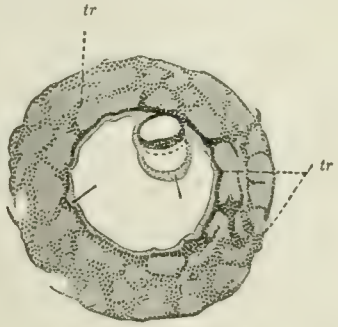


Fig. 1458.—Diagrammatic Section of a Nearly Human Blastocyst. The large space in the interior is the exocœlom. *tr*, Trophoblast. (After Hubrecht.)

formed the *pulmonoperitoneal septa*, and from their dorsal sides the lungs project into the closed pleural cavities. The pulmonoperitoneal septa are finally split into two membranes by the intrusion of air sacs, and the pleural cavities are obliterated by the fusion of the lungs with the body-wall.

*The Mammalian Cœlom.*—The development of the cœlom in mammals, while differing in details in various species, appears always to follow the same general plan. This differs from the order of development in the Sauropsida, in that the primitive divisions of the cœlom appear independently instead of being found by the division of a primitive pair of cavities.

The first to appear is the exocœlom. This begins at the edge of the embryonic shield, and, in the sheep (Bonnet, 1889), spreads rapidly on all sides until it completely separates the yolk-sac from the chorion.

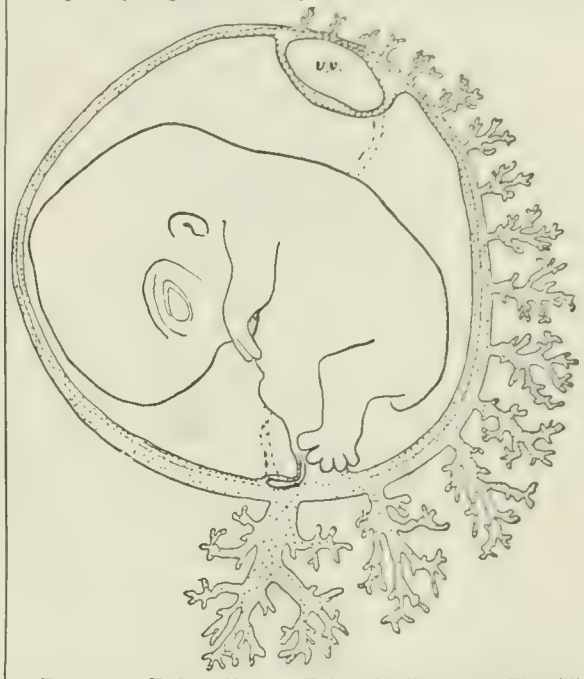


Fig. 1459.—Embryo No. 22. Enlarged 3 diameters. The villi of chorion are outlined on one side only. The umbilical vesicle, *u v*, has become shifted around to the dorsal and right side of the embryo. The outline is made from a photograph, and is correct in detail with the exception of the attachment of the chord to the chorion. This in reality attaches itself to the chorion immediately to the right of the embryo. The exocœlom is obliterated by the fusion of the amnion with the chorion. (From Mall, 1897.)

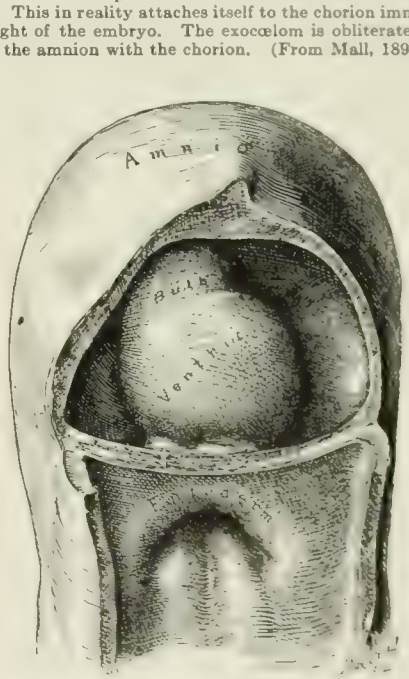

Fig. 1460.—Ventral Aspect of a Human Embryo 2 mm. Long, from a Model of Mall's Embryo No. 391. The ventral wall of the pericardium and the yolk-sac have been removed. The cavity just behind the word "entoderm" is the anterior intestinal portal. × 80. (After Mall.)

In man and the other primates, the early stages are peculiar and are not fully known. In the earliest known

stages of this group the embryonic mass consists of two small vesicles, the yolk-sac and the amniotic vesicle, united by the area embryonalis, and widely separated, except at one point, from the walls of the much larger trophoblastic vesicle, in which they lie (Fig. 1458). In the human embryo, described by

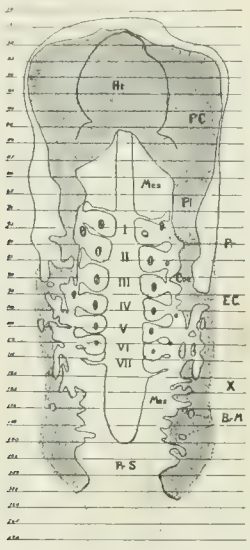


Fig. 1461.—Reconstruction of the Cœlom in Mall's Embryo No. 391. Arabic numerals represent the numbers of sections; Roman numerals, the somites. *Coe*, Peritoneal cœlom; *EC*, communication with exocœlom; *Ht*, heart; *Mes*, mesoderm; *PC*, pericardium; *Pl*, pleural cavity; *Pr*, pronephros; *Pr.S*, primitive streak. (After Dandy.)

Bryce and Teacher, the space between the embryonic vesicles and the trophoblast is filled by a delicate cellular reticulum (Mall, 1910). In Peter's ovum there are indications of an exocœlom partly surrounding the embryonic mass, and in Spee's "embryo von Herff" the reticulum has apparently become concentrated into a distinct layer of mesoderm lining the chorion, covering the embryonic mass, and forming the connective

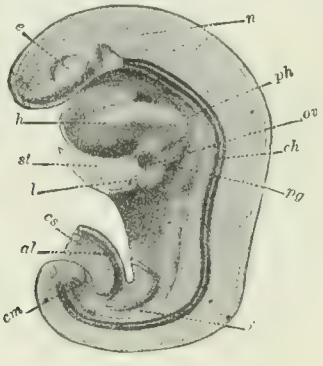


Fig. 1462.—Side View of a Human Embryo 7.3 mm. Long, from a Model of Embryo Wolff II. *al*, Allantois; *ch*, chorda; *cm*, cloacal membrane; *cs*, connective stalk; *e*, eye; *h*, heart; *l*, liver diverticulum; *n*, neuromeres; *ov*, omphalomesenteric vein; *pg*, pulmonary groove; *ph*, pharynx; *st*, septum transversum. (After Keibel and Elze.)

stalk. (See article *Allantois*, Figs. 76 and 77.) Within this layer of mesoderm completely surrounding the embryo, except at the stalks is the large exocœlom. It is filled with an albuminous fluid held together by a delicate network of fibrils that give it a jelly-like consistency (Mall, 1910). At a very much later stage the exocœlom is obliterated by the expansion of the amnion, which ultimately fuses with the chorion (Fig. 1459).

Graf Spee's "embryo Gle" is the youngest human ovum that shows any cœlomic cavities in the body of the embryo. In this, there are traces of the pericardium and of the cardiac angioblast. A sheep embryo with two pairs of somites is in about the same stage (Bonnet, 1889). In the middle of the anterior mass of unsegmented mesoderm on each side irregular splits appear, quickly followed by others in an area extending in a horseshoe shape around the anterior end of the embryo in the head fold and backward to the region of the somites. By the confluence and widening of the splits, a pair of large cavities, the pleuropericardial,

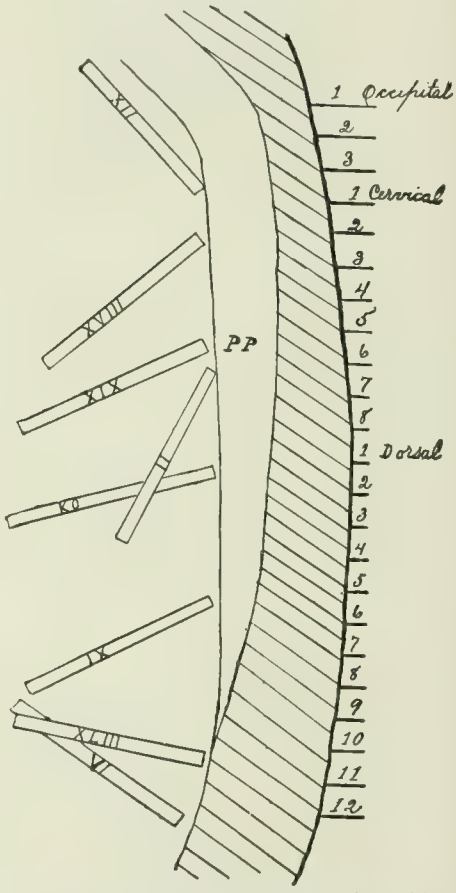


Fig. 1463.—Diagram to Show the Changes in Position of the Septum Transversum. The numbers on the blocks indicate the embryos from which the diaphragms are taken. *KO* is His's embryo K O: *PP*, the outline of the opening between the pleural and peritoneal cavity, which is finally closed when the septum reaches the tenth dorsal segment. (From Mall, 1897.)

or parietal, cavities are formed. From the first they are in communication in the head-fold. By the deepening of the lateral head-fold the parietal cavities are brought together until their inner walls touch, enclosing the endothelial heart in the septum thus formed. The orifice between the two cavities is quickly enlarged by the absorption of the ventral mesocardium from in front backward until it completely disappears (Fig. 1460). In the meantime, more somites have developed and in the older ones myocœls have appeared. The limbs of the parietal cavity extend back to the level of the fifth somite, and are completely separated from the exocœlom. In this region, where the Wolffian body begins to develop, a change occurs

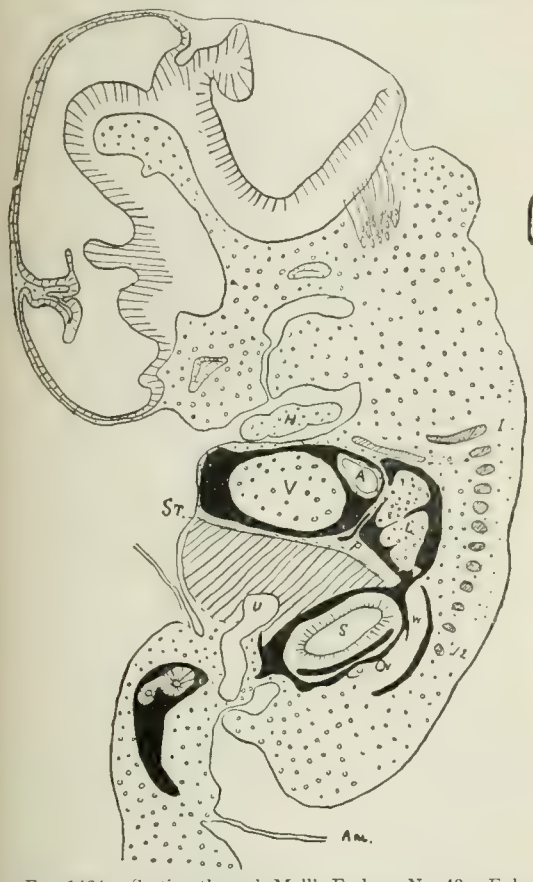


Fig. 1464.—Section through Mall's Embryo No. 43. Enlarged 8 times. *H*, Hand; *A*, auricle; *V*, ventricle; *L*, lung; *S T*, septum transversum; *P*, phrenic nerve; *U*, umbilical vein; *S*, stomach; *W*, Wolffian body; *Ov*, ovary; *Am*, amnion; 1–12, ribs. (From Mall, 1897.)

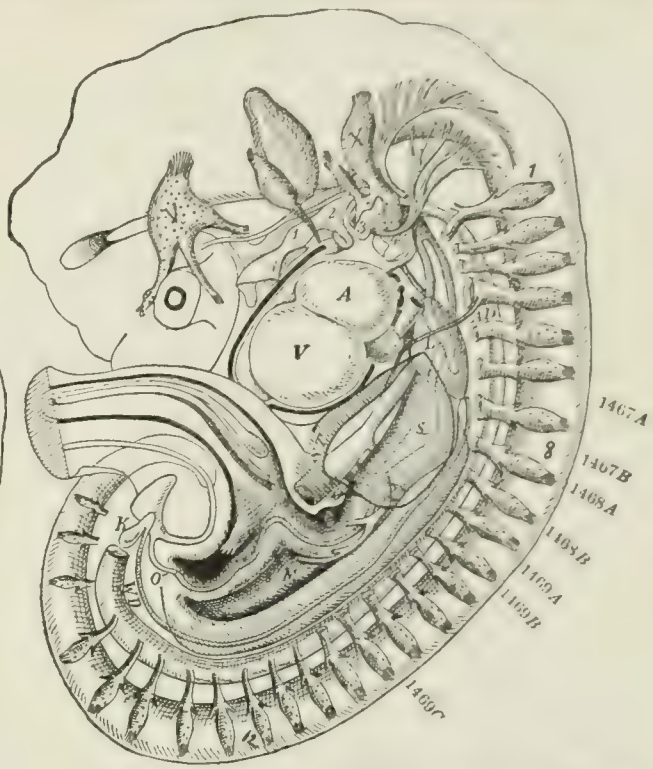


Fig. 1465.—Reconstruction of Mall's Embryo No. 2. Enlarged 17 times. *V* and *X*, Fifth and tenth cranial nerves; 1, 2, 3, and 4, cast of the branchial pockets; 1 and 8, first and eighth cervical nerves, from the fourth the phrenic arises; 12, twelfth dorsal nerve; *A*, auricle; *V*, ventricle; *L*, lung; *S*, stomach; *P*, pancreas; *W D*, Wolffian body; *K*, kidney; *M*, mesentery; *S T*, septum transversum; *O*, openings which communicate with the peritoneal cavity of the opposite side. The black line around the heart marks the pericardial cavity. The numbered lines on the right indicate the planes of sections, Figs. 1467–1469. (From Mall, 1897.)

in the mode of formation of the cœlom. From the fifth somite backward the splitting of the mesoderm continues laterally to the exocœlom. This results in the formation of the peritoneal cavities, which, from the first, open into the parietal cavity in front, and into the exocœlom at the sides of the embryo. This condition is found in a human embryo with seven somites (Fig. 1461). In the sheep, according to Bonnet, a secondary communication is found between the first four myocœls, the parietal cavity, and the exocœlom, imitating the primitive condition found in the lower vertebrates; but behind the fourth somite the myoclœs remain closed.

The liver and the septum transversum are developed in mammals in very much the same way as in the Sauropsida. The liver, however, is usually described as arising by a single diverticulum ventral to the omphalomesenteric veins, (Fig. 1462) and the ventral part of the septum transversum is imperforate from the first, leaving only one pair of openings between the parietal and the peritoneal cavities. These are dorsal to the ducts of Cuvier.

The process by which the cœlom is divided into separate cavities is complicated and difficult to understand because the embryo grows at first more rapidly on its dorsal side, causing it to bend ventrally, and this is followed by the development of the neck and a straightening of the body, with a resulting shifting of the internal organs. The changes in position of the septum transversum are shown in Mall's diagram (Fig. 1463). In a human embryo, about four milli-

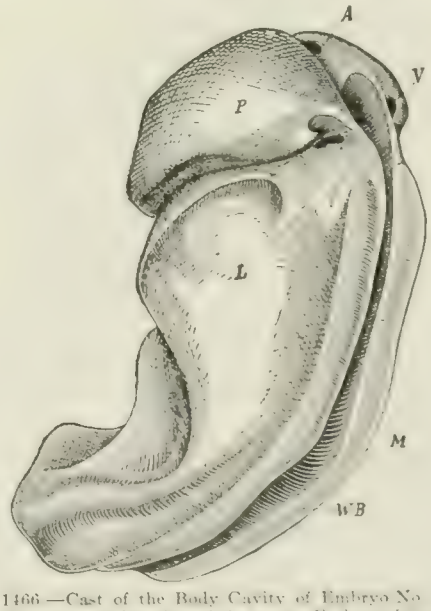


Fig. 1466.—Cast of the Body Cavity of Embryo No. 2. Enlarged 22 times. *A*, Position of the aorta; *V*, duct of Cuvier; *M*, position of the mesentery; *W B*, position of the Wolffian body; *P*, pericardial cavity; *L*, cœlom over liver.

meters long, the dorsal edge of the septum transversum is opposite the second cervical somite and the slope of the septum is ventroposterior. As the body elongates, the dorsal edge of the septum moves backward faster than its ventral edge, so that it turns a half circle. As the result of this shifting of the septum

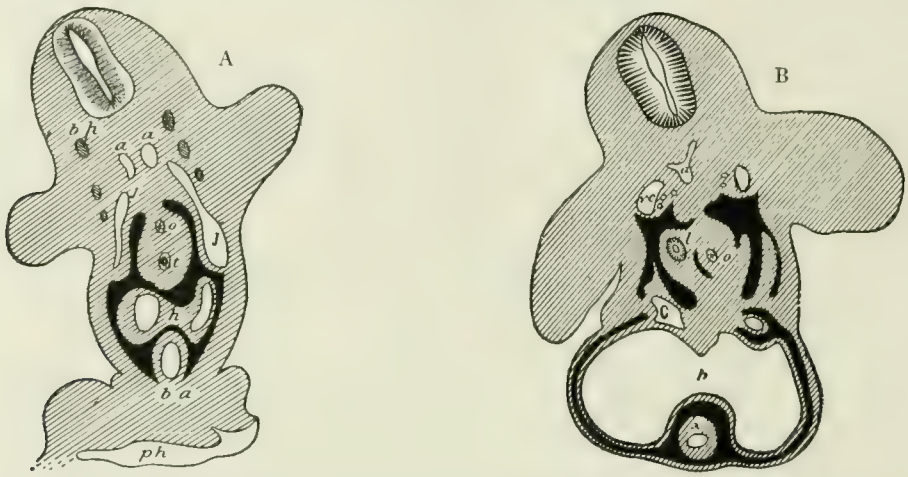


Fig. 1467.—Sections through Mall's Embryo No. 2, at the Points Indicated in Fig. 1465. Enlarged 22 times. *B p*, Brachial plexus; *a*, aorta; *b a*, bulbus aortæ; *ph*, pharynx; *h*, heart; *t*, trachea; *o*, esophagus; *j*, jugular vein; *l*, lung; *v c*, cardinal vein; *C*, Cuvierian duct. The cœlomic spaces represented are in solid black. *B* shows the incomplete pleuroperitoneal membranes connecting with the pleuropericardial membrane dorsal to the ducts of Cuvier. (From Mall, 1897.)

and of the enlargement of the heart, the edges of the lateral mesocardia containing the ducts of Cuvier are carried over the dorsal side of the heart and drawn out in a longitudinal direction. The edges of these two folds unite in the median line and fuse with the walls of the atrium of the heart and with the ventral side of the lung buds, thus closing the pericardium and dividing the pleural cavity into right and left halves. The partition thus formed between the pleural and pericardial cavities is known as the pleuropericardial membrane (Fig. 1469). It is traversed by the phrenic nerve (Fig. 1464) which arises from the fifth cervical nerve, and extends to the septum transversum (*c.f.* Mall, 1910, Fig. 412).

The general form of the perivisceral spaces in a human embryo at this stage is shown by the model represented in Fig. 1466, which should be compared with the reconstruction (Fig. 1465) and with the sections (Figs. 1467–1469).

The separation of the pleural cavities from the abdominal cavity is effected by a pleuroperitoneal membrane, that arises in connection with the pleuropericardial membrane. The united rudiments of the two membranes form what Mall (1910) calls the pulmonary ridge. It arises from the wall of the cœlom on each side of the body along a line that, beginning at the septum transversum or the mesodermal wall of the liver, follows the course of the duct of Cuvier along the dorsal side of the pleuropericardial membrane (Fig. 1469) to the anterior body-wall and then turns and follows the course of the posterior cardinal vein back to the anterior end of the Wolffian body. From this line a sickle-shaped membrane grows into the cœlom on each side, and divides the anterior spaces into the inner pleural cavities containing the lungs and a pair of outer forward extensions of the peritoneal space (Fig. 1470). Growing posteriorly around the lungs, the edges of the two pleuroperitoneal mem-

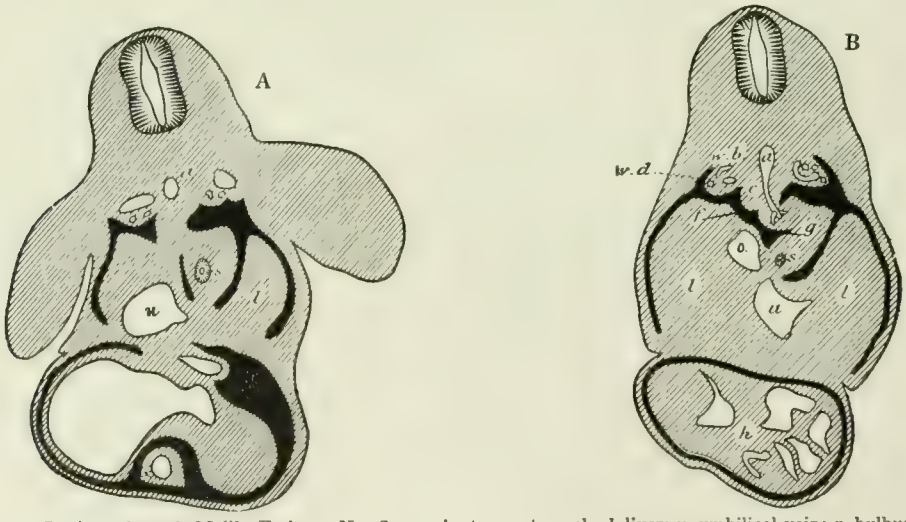


Fig. 1468.—Sections through Mall's Embryo No. 2. *a*, Aorta; *s*, stomach; *l*, liver; *u*, umbilical vein; *x*, bulbus aortæ; *h*, heart; *o*, omphalomesenteric vein; *g*, lesser peritoneal cavity; *f*, foramen of Winslow; *c*, cœliac axis; *w.b.*, Wolffian body; *w.d.*, Wolffian duct. (From Mall.)

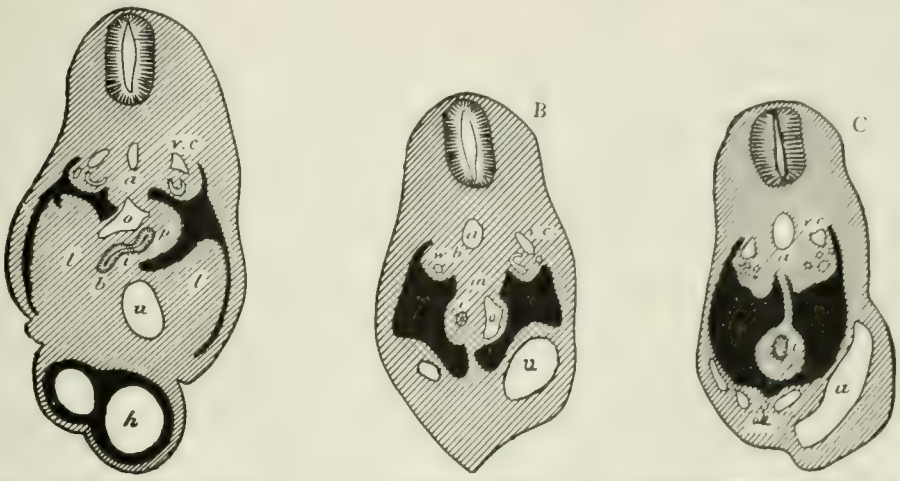


Fig. 1469.—Sections through Embryo No. 2. *a*, Aorta; *ic*, cardinal vein; *o*, omphalomesenteric vein; *p*, pancreas; *i*, intestine; *b*, bile duct; *l*, liver; *h*, heart; *u*, umbilical vein; *m*, mesentery; *wb*, Wolffian body; *all*, allantois. (From Mall, 1897.)

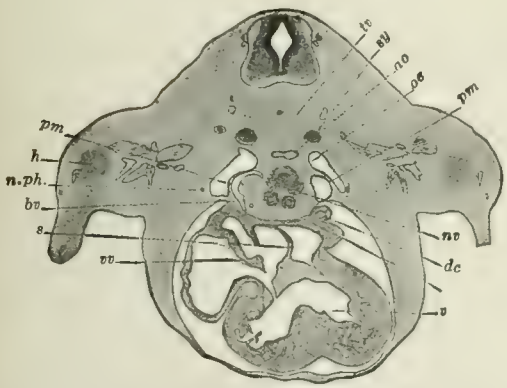

Fig. 1470.—Section of Human Embryo P.I, 11 mm. Long. *ao*, Aorta; *br*, bronchus; *dc*, duct of Cuvier; *h*, humerus; *nph*, phrenic nerve; *nv*, vagus nerve; *e*, esophagus; *pm*, pleuroperitoneal membrane; *s*, septum primum; *sy*, sympathetic nerve; *tv*, thoracic vertebra; *v*, ventricle; *vv*, valvula venosa. (After Keibel and Elze.)

Fig. 1472.—Anterior Aspect of the Diaphragm of a Kitten Seven Weeks Old. The cut surface of the pleura is represented by a dotted line. *ao*, Aorta; *bi*, bursa infracardiaca; *is*, infracardiac space; *e*, esophagus; *vci*, vena cava inferior. Natural size. (After Broman.)

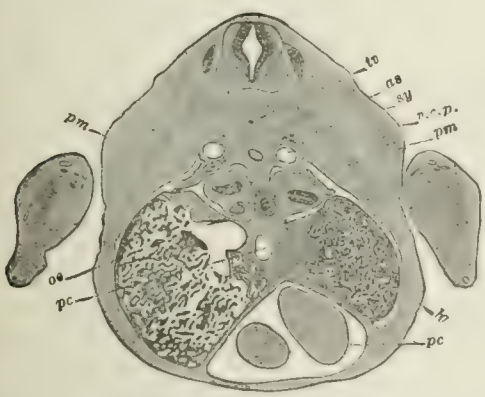

Fig. 1471.—Section of Human Embryo P.I. *lg*, Lung; *pc*, pericardium; *vcp*, posterior cardinal vein; other lettering as in Fig. 1467. (After Keibel and Elze.)

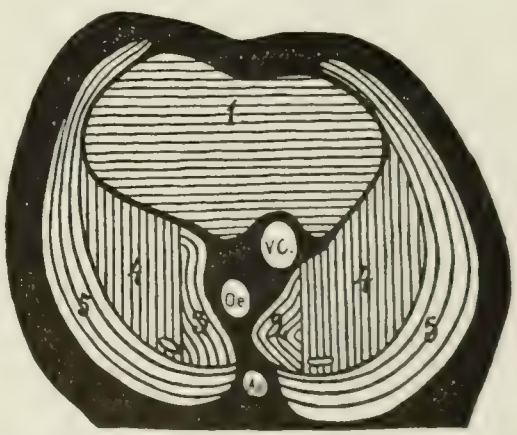


Fig. 1473.—Diaphragm of a Human Embryo 21 mm. Long: *Ao*, Aorta; *Oe*, esophagus; *VC*, vena cava inferior; 1, 2, 3, 4, 5, parts of diaphragm of diverse origin, see text. (After Broman.)

branes approach the median line and fuse on the left side with the esophagus, near where it joins the stomach and on the right side with the accessory mesentery (there being but one in mammals) which bears the vena cava inferior and encloses the forward extension of the lesser peritoneal cavity, the recessus pneumatoentericus dexter. Ventrally the pleuroperitoneal membrane becomes attached to the dorsal surface of the liver (Fig. 1471), along a line formed by the dorsal edge of a mass of mesodermal tissue that is continuous with the septum transversum and extends dorsoposteriorly from it over a part of the surface of the liver. Thus the pleural cavities are closed. Before this closure is completed, two other processes have

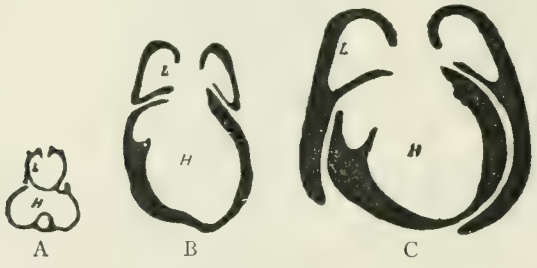


Fig. 1474.—Outlines of the Pleural and Pericardial Cavities to Show Their Relative Position and Size. Enlarged 7 times. *A*, Mall's Embryo No. 2; *B*, Embryo No. 9; *C*, Embryo No. 22. *H*, Position of heart; *L*, position of lung. (From Mall, 1897.)

begun. One is the formation of the bursa infracardiaca, and the other is the partial isolation of the septum transversum from the pericardium and from the liver.

The *bursa infracardiaca* (Fig. 1472) is a closed sinus lying on the right side of the esophagus near the diaphragm. It is formed from the anterior end of the recessus pneumatoentericus, which is separated from the rest of the lesser peritoneal cavity by the fusion of the accessory mesentery with the esophagus near the cardia of the stomach. According to Hochsetter

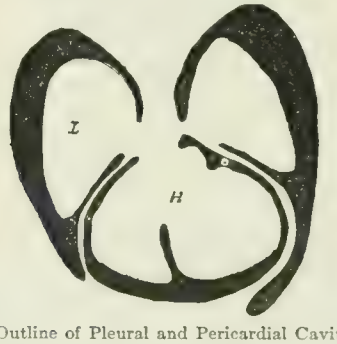


Fig. 1475.—Outline of Pleural and Pericardial Cavities in Mall's Embryo No 45. Enlarged 7 times. (From Mall.)

(1913) it is entirely obliterated in man and in other mammals that do not possess an infracardiac lobe of the lung. But according to Broman, it is to be found in all human embryos and probably in most adults.

The partial isolation of the septum transversum is an important phase in the development of the diaphragm. The mammalian *diaphragm* is an organ of complex origin, being derived (Fig. 1473) (1) from the septum transversum, (2) from the accessory, (3) from the chief mesenteries, (4) from the pleuroperitoneal membrane, and (5) from the body-wall. At first it is entirely free from muscular elements, which grow into it secondarily from the body-wall. The septum transversum, at first a layer of connective tissue, uniting the liver with the pericardium, retains some of this connection throughout life. The process by which it is converted into a membrane continuous with the pleuroperitoneal membrane is similar on the two sides. Posteriorly the peritoneum insinuates itself between the connective tissue of the septum and the substance of the liver, forming the coronary and falciform ligaments.

At the anterior side the pleuropericardial membrane is at first entirely dorsal to the heart, but by the burrowing of the pleura into the body-wall the pleuropericardial membrane is extended around the sides of the heart (Figs. 1474–1476) until the pleuræ meet on the ventral side of the heart, forming the ventral mediastinum, a more or less complete membranous pericardium, and separating the latter more or less from the diaphragm. In man and other mammals that lack

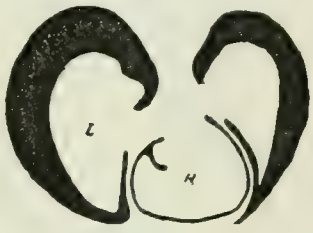


Fig. 1476.—Outline of Pleural and Pericardial Cavities in Mall's Embryo No 34. Enlarged 3 1/2 times. *H*, Position of heart; *L*, position of lung. (From Mall.)

an infracardiac lobe of the lung the posterior part of the pericardium is continuous with the diaphragm; but in cats, rabbits, and many other mammals there is an infracardiac lobe of the right lung and this lies in the infracardiac space (Fig. 1472), a pocket in the mediastinum lying posterior to the heart and opening into the right pleural cavity between the inferior vena cava and the esophagus. In these animals the pericardium is connected to the diaphragm only by the mediastinum.

The development of the omental sac and of the peritoneal sacs of the scrotum has been sufficiently described in previous paragraphs.

Robert Payne Bigelow.

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**Co-enzymes** are substances whose presence is necessary for the activity of certain enzymes. Co-enzymes in reality are not enzymes at all, since they are resistant to heat. They might be called more correctly activators. The influence of these co-enzymes is seen in the fact that solutions of enzymes may be made inactive by dialysis and again become active on the addition of boiled enzyme or the concentrated dialysate. As another example may be cited the necessity of the presence of an acid for the action of pepsin. FRANK P. UNDERHILL.

**Coffee.**—The seeds of *Coffea arabica* L. (fam. *Rubiaceæ*). Coffee itself is not official, having been replaced by its alkaloid (see *Caffeine*).

The coffee plant is a good-sized shrub or small tree, with opposite spreading or horizontal branches, and dark green, glabrous, nearly evergreen leaves. The white flowers grow in close clusters in the axils of the leaves. Farther down are the green and then the red fruits, the whole being highly ornamental. The fruit is an oblong, rounded, scarlet or purplish, slightly juicy drupe, with a thin, fleshy mesocarp, and a papery endocarp, loosely enclosing the two seeds. It is about two centimeters long ($\frac{1}{2}$ to $\frac{3}{4}$ in.).

This shrub is a native of tropical Africa, where it grows very extensively upon both coasts, and far into the interior. It is also cultivated in most of the warm parts of the earth, especially in Java and Brazil.

FIG. 1477.—Branch of the Coffee Tree, *Coffea arabica*, with Fruit. (Baillon.)

Our earliest knowledge of coffee came from Arabia, where it was introduced from Abyssinia at least 400 years ago. It was introduced as a drink into Europe by way of Constantinople, reaching London and Paris about the middle of the seventeenth century. Its cultivation was begun in Batavia at about the end of the same century, and in the beginning of the next it was being raised in India, Brazil, and the West Indies. The plants and the berries of these different countries present slight variations. Mocha coffee is small, plump, and dark yellow; Java larger and paler, and the Indian and American coffees larger and greenish-gray or bluish-gray. Mocha has the richest flavor, Java is one of the most delicate, and some of the West India and the Brazilian kinds are coarser and less fragrant. *Coffea liberica*, of Western Africa, produces a larger seed, with a strong, full, but rather rank, flavor, known as Liberian coffee. Age, before they are roasted, improves them all. Coffee leaves themselves contain caffeine, and are used as a beverage in the East.

Coffee is raised in orchards, where the trees are set in rows; trimmed and tended, they are long-lived and bear for many years. Two crops are usually produced each year. The pulp of the fruits is separated, usually by mechanical means, and the papery endocarp, when dry and brittle, is broken and rubbed away. The testa of the seed is usually also absent in commercial coffee, excepting on the face, where it enters the ventral fissure.

COMPOSITION.—The most interesting ingredient, *Caffeine*, is described elsewhere. It occurs in coffee in combination with *caffeo-tannic acid*, in varying proportions between one-half of one per cent. and two and three-tenths per cent. The quality of the coffee, as usually estimated, depends only partially upon its amount of alkaloid. Of the caffeo-tannic acid, the yield is from four to five per cent. Besides these, are *fixed* oils, from fourteen to twenty-two per cent., *dextrin* from fourteen to sixteen per cent., a large amount of *albuminoid matter*, and a very minute amount of *volatile oil*. Roasting changes the character of coffee very materially, dissipating a little of its caffeine and most of its water, and forming some fragrant decomposition products not much understood. The seeds lose about fifteen or twenty per cent. in weight, and gain much more than that in volume. The sugar and dextrin are changed to caramel, and the soluble portions in general are diminished.

Unground coffee is seldom adulterated, but ground coffees are apt to be adulterated, the world over, by grains of various kinds. Of these admixtures, beans and chicory roots are the most important. It is better to purchase the whole seed than to puzzle over the mixtures. Pure ground and burnt coffee shaken in water does not immediately discolor it, as most of the imitations do.

ACTION AND USE.—The effect of coffee is in the main the same as that of caffeine, a nervous and cardiac stimulant, and a raiser of blood pressure; but it has in addition a pleasant, exhilarating effect upon the feelings, which is probably in part also due to aromatic ingredients contained in it, or developed by the roasting. It is occasionally given for sick and neuralgic headaches, and to counteract the disagreeable after-effects sometimes produced by opium; and in opium poisoning, which it mildly antagonizes by its stimulating effects upon the brain and circulation. The universal use of coffee, however, greatly restricts its usefulness as a medicine. Its excessive use, or its use by those unfortunately sensitive to it, produces wakefulness, "nervousness," confusion and incoherence of thought, palpitation and irregular action of the heart, and dyspeptic troubles. The excessive use of coffee is believed in Oriental countries to be responsible for many cases of blindness, and it certainly causes disorders of vision when sufficiently abused to disturb the nervous equilibrium.

The dose of coffee for, say, headache, is about ℥ ss. (15.0) in infusion, that is, a coupful made strong and "black." A fluid extract is to be had if desired.

H. H. RUSBY.

**Cohnheim. Julius.**—Born in Demmin, Pomerania, on July 20, 1839. After pursuing his medical studies in Würzburg, Marburg, Greifswald, and Berlin, he received the degree of Doctor of Medicine from the latter university in 1861. In 1864 he was made an assistant in the Pathological Institute at Berlin. During the preceding years he published, in Virchow's Archiv (No. xxxiv.), an article on the minute structure of the striated muscular fibers, and in this article he described for the first time the method of freezing tissues for the purpose of examining them in the

fresh state under the microscope. In 1867 he published, again in Virchow's Archiv (No. xxxviii.), an article entitled: "Ueber die Endigung der sensiblen Nerven in der Hornhaut," and in it he gave a description of the so-called "gold method" of differentiating nerve fibrils from the surrounding tissues, in thin sections prepared for microscopic examination—a method which he had himself recently discovered. In this same year he published (Virchow's Archiv, No. xli.) his celebrated article on "Entzündung und Eiterung"—an article in which he characterizes the emigration of the white blood corpuscles from the blood-vessels as the essential feature of suppuration. This declaration

Fig. 1478.—Julius Cohnheim.

on the part of Cohnheim created a veritable revolution in the views which pathological anatomists were at that time holding. In 1872 he was made Professor of Pathological Anatomy and General Pathology in Breslau. In the winter of 1873–1874 his health began to break down, and he was obliged to give up for a time the work of teaching. In 1878 he accepted a call to fill the Chair of Pathological Anatomy in the University of Leipzig, and it was during his residence in that city that he completed the second edition of his great work entitled "Allgemeine Pathologie" (Berlin, 1882). He died in Leipzig on August 15, 1884. After his death a complete collection of his writings was published in Berlin. (Pagel.)

As a teacher Cohnheim possessed to an extraordinary degree the gift of stimulating his pupils. These came to him from every part of Germany, and, after they had become inoculated with his enthusiasm for carrying on research work, and had learned his helpful methods of arriving at the truth, they began to publish over their own names valuable papers on a great variety of pathological themes. It would therefore scarcely be possible to overrate the number and the degree of importance of the contributions which this one man has, directly and indirectly, made toward the advancement of medical knowledge. A. H. B.

**Cohosh, Black.**—See *Cimicifuga*.

**Cohosh, Blue.**—See *Caulophyllum*.

**Coitus.**—Sexual contact or copulation is essential to the process of reproduction in all the more highly organized species of the animal kingdom. An analogous step in the process has in fact been traced upward from a comparatively early phase of plant life, for sexual reproduction is the rule among all but the lowest orders of plants. Actual contact is, however, exceptional. In most of the flowering plants fertilization depends upon an indirect transfer of pollen through the medium of air or water or by the agency of insects. Yet, on the other hand, in some of the lowest forms of cryptogams, flowerless plants, more or less intimate contact or union of two individuals is necessary, and in some of the higher species of thallogens the union closely resembles that of the animal kingdom.

In the lower forms of animal life much difference is observed both in the manner and in the duration of the connection, and in not a few instances peculiar changes occur in some of the organs or parts of one or both sexes for the purpose of copulation. Earthworms, for example, become firmly united, two segments of each having previously undergone necessary changes. In some orders of the crustacea the male organ resembles a rudimentary foot which is thrust into the vulva. The true character of this appendage is demonstrated by the presence in it of a vas deferens. A similar transformation of a member is seen among the cephalopods; for in some species of the cuttlefish the male and female become firmly attached to each other, mouth to mouth, with the suckers of the arms in apposition. While thus embracing, one of the arms is detached by the male and it is deposited within the mantle of the female. The arm thus detached has been previously "hectocotylized," that is, a sac filled with spermatophores has been formed upon it. These are discharged within the mantle and are carried to the ova through a tube which perforates the terminal filament.

Among insects the alteration of limbs and abdominal segments is sometimes quite remarkable. Reproduction is invariably a result of sexual union except in a few instances of hermaphroditism. Among the hymenoptera (bees, ants, flies, etc.) the connection lasts from a few seconds to several hours. The male bee is sometimes so injured by prolonged contact that his death immediately follows the separation. The fantastic position of the dragon-fly during copulation is due to the peculiar position of the organs in the two sexes. That of the male is situated in a slit on the undersurface of the second abdominal segment, that of the female on the under surface of the eighth segment. In spiders we find conditions which more resemble those seen in some of the cephalopods than in the insects, for the spermatic fluid is deposited in a receptacle in the chela, or claw, and is then thrust into the cloaca. The first appearance of a true penis is found among the amphibia.

Among the vertebrates also there is a gradual transition from a very simple to a more complicated method of copulation as we ascend from the lower to the higher orders. In the former the organs are rudimentary, recalling the altered segments of the earthworm. Some species of fish do not copulate; fertilization of the eggs occurs after they are in the spawn. In some there is a momentary contact, while others are said to remain united until they are accidentally separated. In some elasmobranchs peculiar "claspers" at the posterior extremity of the male, supposed to be rudiments of a third pair of limbs and intended primarily for maintaining contact, seem to be partially introduced. Among birds there seems to be no deviation from the copulative method of fertilization, but the process varies from a momentary contact in the smaller species to one as complicated as that of the higher quadrupeds in some of the larger, notably in the ostrich.

The monographic literature on the subject of human copulation is extremely limited in comparison with its importance. This must be necessarily the case, because knowledge rests upon obervation and experiment; and a theme like copulation cannot with our present ideals and sense of value be submitted to scientific treatment. Nevertheless during the past decade an enormous literature on sex lore of all conceivable characteristics has come into existence which naturally comprises many data belonging to coitus. Exact and systematic learning cannot, however, be

compiled from such data and we can only conclude that coitus is a very complicated affair with many secondary features.

Considered merely in its relation to procreation, copulation, in the human being, consists essentially in nothing more than the deposit of seminal fluid within the vagina, even in the vestibulum, for it is well known that conception may occur without actual penetration. This would limit the act in the male to the period of life between puberty and an indefinite time of old age, and in the female to the period of ovulation. A man may procreate so long as his seminal fluid contains living spermatozoa, although he may be able to perform the sexual act but imperfectly; but in the female the possibility of impregnation ceases with the completion of the menopause. But no such limit can be drawn. The ability of the male to copulate, as the term is ordinarily understood, depending almost wholly upon erection of the penis, begins in early childhood and lasts until the development of senility. There is practically no age limit to its possibility in the female after childhood. The part taken by the male and the female will be more conveniently considered separately.

*The Male.*—To place a physiological limit upon the frequency of copulation in the male is hardly possible, for in the human being there is no such natural limitation as we see in most of the lower animals, and under the many exciting influences of civilization, sexual desire is exceedingly variable. Neither is desire a proper criterion of the normal requirements, for in some men it is aroused not merely by the accumulation of seminal fluid after prolonged continence, which seems to be the normal stimulus, but by the perception of an attractive woman through any of the senses or even by the imagination alone. Although we admit that the testicular secretion is constant and that absolute continence is not strictly physiological, still the normal limit of indulgence may undoubtedly be exceeded. A man may indulge so frequently that, although he experiences the usual excitement and an apparently normal orgasm, the ejaculated fluid becomes devoid of fecundating property. Such frequency is clearly abnormal. It is generally followed by undue depression if not by more lasting evil effects. On the other hand, it must be admitted that the evil effects of continence are seldom of consequence in the absence of unnatural excitement and uninfluenced by previous immoral practices. The emergency rarely arises in which the physician can recommend illicit intercourse without compromising himself professionally as well as morally. Within the bounds of legitimacy there can be no question that the practice should not exceed the gratification of natural desire, a desire which varies, however, with the physical vigor and health of the individual, his mode of life and climatic influences, and usually diminishes to some extent with advancing age.

The anatomy of the male organs is appropriately considered in another volume of this work, and it will be necessary therefore to describe only briefly the mechanism of erection. It has been shown that the erection and rigidity of the penis depend upon a temporary increase in the size of the arterioles which supply blood to the erectile tissue of the spongy and cavernous portions, more than upon constriction of the veins which carry away the blood; but such constriction probably increases the turgescence, especially for a short time during the period of greatest excitement. The nervous control of these vessels comes from the sacral plexus and is practically the same as that of the integument and muscles of this entire region.

The sensation experienced in coitus depends for the most part upon the sensitiveness of the glans, the acuteness of which increases with the rigidity; it is aided by nervous excitement and by friction within the vagina until the orgasm occurs. As this stage is reached a different sensation is developed, probably by increased peristaltic action of the vesiculæ seminales and by the rhythmical contraction of the bulbo-cavernosus muscle, which culminates in the forcible discharge of semen. Following this the venereal excitement quickly gives place to a variable degree of lassitude and the sensitiveness of the organ to a feeling resembling fatigue.

As already stated coitus is in reality a much more complicated affair than is commonly thought. Beginning with mere coitus movements nearly all the motor activity possible to a man is extended throughout his organism. At the climax or orgasm he experiences often what is hardly distinguishable from an epileptic convulsion. In regard to the human position of copulation there must have been an evolutionary period in which the brute position was used. Still even now the organs, especially of the negress, are by no means unfavorable for the brute position. The change in the latter was doubtless of much significance in the evolution from quadrupeds to mankind.

*The Female.*—The part of the female is passive, at least to a much greater degree than is that of the male. In some women there is no feeling of pleasure, much less an orgasm comparable to that of the consort. Others undoubtedly experience sensations fully equal to those of the male. Conception is probably more likely to occur when full venereal excitement is experienced, yet it is by no means conditioned upon such enjoyment, for it may result from connection in a state of unconsciousness. The mechanism of the act closely resembles that of the male. The parts are supplied by a corresponding set of nerves and the circulatory changes are the same in nature. There is a certain degree of erection of the clitoris which causes it to become more acutely sensitive, and of the erectile bulbs at the sides of the vulva. The erectile tissue of the vagina also participates and there may be an ejaculation from the glands of Bartholin opening at the sides of the labia minora. To what extent the higher organs are involved is not definitely known. The uterus sinks lower in the vagina and the cervix is said to become softer. A certain amount of erection takes place in the uterus, by contraction of its muscular fibers and those of the round ligaments, and the cavity is thus reduced in size, causing the expulsion of a few drops of mucus from the os. The subsequent relaxation is supposed to favor the entrance of seminal fluid if it does not in reality draw it in as by aspiration. No one has yet confirmed the descriptions by Litzmann, in 1846, and by Beck, in 1872, of a gasping, opening and closing of the os as a part of the orgasm. For the consideration of the method by which the spermatozoa are carried through the upper passages the reader is referred to the article on *Impregnation.*

The normal frequency of copulation in the female is more difficult to determine than in the male, for desire is more variable and excess as a rule is better borne. There should certainly be a respite, however, during menstruation, in the latter period of utero-gestation, and for several weeks after confinement.

Copulation may be incomplete from various causes; it is not infrequently so in the first experience of either party to it. The undue nervous excitement of the male sometimes ends in a loss of rigidity or in premature ejaculation. An unduly rigid hymen, an undeveloped condition of the vagina, narrowness of the orifice, or other abnormality may prevent entrance.

Various accidents occur. Lacerations and abrasions of the penis are usually of no importance except with reference to the possibility of infection. Edema or ecchymosis of the skin occasionally follows undue violence. Urethral hemorrhage sometimes occurs, frequently from rupture of a stricture. Cases are reported in which the root of the penis has been dis-

located. The so-called fracture consists in a rupture of the corpora cavernosa and may result in such deformity as to render future coitus impossible. Quite a number of cases have been recorded in which the great contraction of the vagina aided by that of the levator ani rendered separation after coitus difficult or impossible until various remedies had been applied. This result seems to have followed the application of musk to the vagina in several instances. More or less complete epileptic seizures sometimes occur during or after connection, most frequently accompanying the orgasm, particularly in the female. Death has also been reported in not a few instances, but its immediate cause has generally been cerebral hemorrhage, the rupture of an aneurysm, or organic heart disease.

The injuries to the female are sometimes serious in character; they are especially liable to occur as a result of the assumption of unnatural positions. The rupture of the hymen is generally of no consequence, but the rent occasionally extends so deeply as to involve the mucous membrane of the vagina and thus give rise to serious hemorrhage. Laceration of the perineum, the clitoris, the urethra, or the anterior vaginal wall into the bladder and similar accidents have been reported. Uterine hemorrhage is not seldom induced, especially by the first connection when it occurs soon after menstruation, and is sometimes of considerable severity. There is evidence to show that at one time the vagina was much more able than now of playing an active rôle in coitus Though the increased power of the constrictor cunni, levator ani, and musculature of the vagina it could well by friction and aspiration cause an orgasm in the male. Survivals of this sort are still met.

The same holds good for the "tubal orgasm" which some women appear to undergo and which is believed to represent a rapid contraction of the tube involving the "bringing down of the egg." Some women appear to regard the peculiar sensation as indicating that conception has occurred; while others look upon it as a sort of emblem of good fortune.

The medicolegal aspects of this subject will be found under the title of *Rape, Medicolegal Aspects of.*

James M. French.
Edward Preble.

**Cola** (N. F.).—*Kola* or *Kola Nut; Semen Kolæ* or *Colæ; Guru* or *Gooroo Nuts; Bichy* or *Bissy Nuts; Soudan Coffee.* The fresh or dried cotyledons of *Cola vera* Schum. or of *C. acuminata* (Beauv.) Schott. (fam. *Sterculiaceæ*). These plants are medium-sized trees of western tropical Africa, cultivated there and elsewhere in tropical regions and extensively naturalized in the West Indies. The commercial product is obtained from both cultivated and wild trees and both from the West Indies and from Africa. The seeds grow from one to three in each of the four to eight cells of a large woody capsule, the cells of which split open at maturity. The seeds possess a thick, softish testa, which is allowed to soften by partial decay for some days, when it is removed. The cotyledons, two in the first-named species, which is preferred, three or four in the second, constitute the whole of the kernel. This kernel is very thoroughly washed in the purest of water. If to be exported in an undried condition, those which are still entire are then enwrapped in the large leaves of a related species, and packed carefully in baskets. If kept carefully, they will remain fresh for many weeks and, thus imported, they constitute our "fresh kola." Otherwise, they are dried in the sun, when the cotyledons usually separate. There can be little doubt of the greater activity and superior properties of the undried kernels.

For native consumption, they are used entirely in the fresh condition, and are mostly caused first to enter the incipient stage of germination. Opinion differs as to whether this operation changes them only by a sweetening process, due to the conversion of some starch into sugar, or whether, as claimed by the natives, their nervine action is thus increased.

Description.—The fresh kernels are irregularly oblong, or ovoid, somewhat inclined to be bluntly angled, slightly compressed one way, usually with a slight fissure indicating the division of the cotyledon; about one to one and one-half inches long, not quite so broad and about two-thirds as thick. The surface is smoothish, somewhat granular, the color purple to brown, the texture tough-fleshy, the odor somewhat aromatic, the taste aromatic, bitterish, and astringent. In the dried condition, the above bodies are mostly separated into halves, reduced about a third in size by drying, each somewhat bent, thus becoming irregularly planoconvex, or the flat side even a little concave. The edge is thin and quite sharp, the color dark-brown, the outer surface granular, the inner smooth, the consistency hard and quite tough. They have almost no odor and the bitterness and aroma are nearly lost, the astringency being mostly retained.

Constituents.—Much effort has been bestowed upon attempts to determine the presence of constituents which can explain the remarkable statements which have been made concerning the effects of the native use of kola, but, as usual in such drugs, these constituents, if they exist, are elusive. Besides about one-tenth per cent. of volatile oil, forty per cent. of starch, and from two to four per cent. of tannin, the important constituents are alkaloidal, to the extent of about two to four per cent. A very slight amount of this alkaloid is theobromine, the remainder caffeine. About half of this caffeine exists free, the remainder combined with the tannin (*kola-tannin*) as *kolanin.* Although the latter compound is said not to be a glucoside, yet it is decomposed by a special enzyme, after the manner of glucosides in seeds. A peculiar coloring matter, *kola red,* is also yielded.

Action and Uses.—Kola is to the native of Africa what coca and maté are to the South American, and marvellous tales are told of the amount of work and fatigue that the African is enabled to endure when supported by the stimulating properties of this seed. It has been held in the greatest esteem from time immemorial, and is now looked upon almost as a necessity.

In addition to its ordinary use, it has acquired a reputation as a specific in counteracting the depressing and debilitating effects of alcoholic intoxication. Experiments have been made with it in the French army which prove that it has decided stimulating properties, but is in no sense a food.

The kola nut and its physiological action were treated in a thorough manner by Dr. Monnet in 1884, under the direction of Dr. Dujardin-Beaumetz, and an abstract of his thesis was published in the *Therapeutic Gazette* in the following year. The physiological and therapeutic actions are summed up by him in the following conclusions:

1. Kola, by virtue of the caffeine and theobromine which it contains, is a tonic of the heart, whose pulsations it accelerates, while it increases its power and regulates its contractions.

2. A second phase of its action, similar to that of digitalin, proves it to be a regulator of the pulse, which revives under its influence, the pulsations becoming fuller, and less numerous.

3. In consequence of its action upon arterial tension, diuresis is increased, and, consequently, kola can be employed to good advantage in cases of dropsy with cardiac lesion.

4. It might be deduced from observation that kola,

which acts energetically upon cardiac contractions, and upon the contractility of muscles of organic life, would, on the other hand, have a paralyzing influence upon the striated muscles, when it is used in toxic doses.

5. It retards tissue metamorphosis and diminishes the excretion of urea resulting from decomposition of azotic substances, very likely by exerting a special action upon the nervous system.

6. It is a powerful tonic, through the principles which it contains, and its employment is indicated in cases of anemia, in chronic affections associated with debility, and in convalescence from acute disorders.

7. It favors digestion, either by augmenting the secretion of the gastric juice (eupeptic), or by acting on the fibers of the stomach, which it would render less atonic in cases of dyspepsia. Under its influence, rebellious anorexia disappears and the digestive functions become more regular.

8. Finally, it is an excellent antidiarrhea remedy, and has rendered great service in chronic diarrhea or sporadic cholera, although its action could not be explained physiologically.

It is to be noted that the above results were doubtless reached by the use of the dried kernels, in which the kolanin compound is in decreased amount. The question of the relative action of free caffeine, and of the same amount taken into the system in a combined state like kolanin, is an important one. It appears reasonable to suppose that there would be an important advantage in degree, if not in kind, if the latter method were employed; and reports must be judged differently, according to which of the two forms was employed.

Surgeon R. H. Firth publishes (*Practitioner*, July, 1889) some very practical observations made upon British troops and natives under his control, and concludes that kola is in no sense a food, and that its physiological action is explained by the contained alkaloids; when pure and not too old, it has a peculiar stimulant action upon the nervous system, temporarily strengthening the heart beat, and increases the arterial tension; taken continuously during times of exertion and fasting, it possesses some power of warding off the sense of mental and physical exhaustion. This power, however, is not so marked as some observers have reported; in the convalescence from long sickness, its value is not apparent, and its alleged antagonistic action to alcoholic sequelæ is not capable of proof.

The use of kola among pedestrians and athletes has gained some popularity and repute.

As a therapeutic remedy, it is of benefit in strengthening the weak heart, augmenting the general flow of blood and vascular tension, and promoting diuresis. Its tonic effect has also proved of benefit in disturbances of the nervous system and debility of the cerebrospinal centers, and in the prostration accompanying and following severe fevers and protracted illness. As a remedy for diarrhea, particularly of an atonic character, it has proved of decided value. The combination of the tannic acid and its tonic principles makes it of great service in this disorder. The preparations advised are the alcoholic tincture, the elixir, and the wine. The tincture is made by exhausting fresh kola with five parts of alcohol, and the wine by macerating the same proportions of kola in wine for a fortnight. The dose is from one to two or three teaspoonfuls three times a day. The elixir is prepared by diluting the alcoholic preparations with equal proportions of syrup.

HENRY H. RUSBY.

**Colchicum.**—*Meadow Saffron.* A genus of plants of the lily family (*Liliaceæ*), comprising about thirty species, one of which, *C. autumnale* L., yields two official drugs, namely, the corm (*Colchici Radix*) and the seed (*Colchici Semen*). As these drugs, both official, are identical in properties and use, and practically so in composition, they are considered together. The Pharmacopœia requires that the corm contain not less than 0.35 per cent. and the seeds not less than 0.4 per cent. of colchicine. The plant is a perennial herb, with a very short subterranean upright stem, arising from the apex of a corm, and having at its side another corm, younger or older according to the season.

The corm of colchicum, in the latter part of the summer, when it is usually gathered, is principally composed of that portion which has just done service in ripening the fruit. It is about five centimeters long by four in width ($2 \times 1\frac{1}{2}$ ins.), and enclosed in two brown papery coats. It is irregularly pear-shaped, rather pointed above, blunt and oblique at the base,

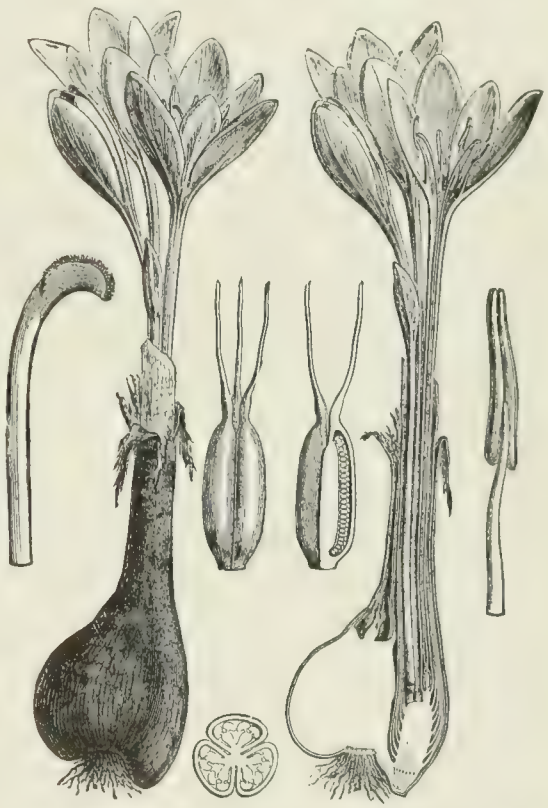

FIG. 1479.—Colchicum. Flowering plant, one-half natural size, and details of structure; also seed. (Baillon.)

and flattened and grooved on one side, where it clasps the new growth. At the apex is the scar or remains of the now decayed aërial vegetation. At the base, on the flattened side, is attached the new bud which is to produce the flower in the autumn, enclosed in the general coverings above mentioned. Later in the season the stem and flowers of the young bulbs form a column at the side of the old one, fitting into its flattened or grooved surface, and having the appearance of being simply a lateral bud of the older corm. During the following spring, however, the elder tuber shrivels away, and the new one, as its fruit ripens, becomes large and plump, and in its turn develops a junior for the succeeding fall.

Colchicum is a native of Middle, Southern and Eastern Europe. It is frequent also in England, and is occasionally cultivated, for its pretty but somber flowers, in this country. Our medical supply of the root comes principally from England and Germany. The corms are usually collected in midsummer, or

shortly after, when they are the plumpest and finest looking. From this time until fall they do not change much, and if gathered when in flower would be probably equally good. They are sometimes used abroad in the fresh state; sometimes also dried whole. Usually, however, and always for this market, they are sliced and dried by the aid of gentle heat. Their quality is very sensitive to carelessness in drying. The seeds are simply collected and dried when ripe.

Description.—*The Corm.*—The transverse slices into which the corm is cut are about three millimeters ($\frac{1}{8}$ in.) thick, and from one to three centimeters in diameter, according to their position. Their cut surfaces are white or grayish white, their edges (surface of the corm) brownish yellow. In shape they vary a little; those cut from the upper part may be simply round, but those of the middle and lower portions are flattened or indented at one side, where the flower buds lie, or they may even be typically kidney-shaped. The drug is occasionally sliced vertically, when the slices will be more or less ovate, and some of them longitudinally grooved. Even the whole corms are sometimes met with. They are hard, brittle, and loaded with starch. Taste very bitter and acrid, odor simply earthy. That which is very dark colored internally, or breaks with a horny fracture (showing too much heat used in drying), should be rejected.

The *seeds* are of more modern use, having been introduced about sixty years ago. They are sub-globular, about two millimeters ($\frac{1}{16}$ in.) in diameter, very slightly pointed at the hilum; surface reddish brown, finely pitted and dull; internally whitish; odor none; taste bitter and acrid; texture very hard, bone-like between the teeth, at the hilum a soft caruncle.

Composition.—The corms, in drying, lose two-thirds of their weight, and when about dry consist largely of starch, in fine rounded, by mutual pressure polyhedral, and sometimes compound grains. Sugar, gum, resin, fixed oil, etc., are other common substances contained in them. The seeds also contain sugar, resin, fixed oil, etc., as incidental constituents. Both contain, as their peculiar principle, a little more than one-third of one per cent., the seeds rather more than the root, of the intensely active substance *colchicine*. It is also present in the leaves. Colchicine ($C_{15}H_9$ [$OCH_3$]$_4$[$NHC_2H_3O$] [$CO_2CH_3$]) is a very bitter and extremely poisonous alkaloid, occurring as a yellow, crystalline powder, soluble in both water and alcohol. It yields *colchiceine*, or aceto-trimethyl-colchicinic acid, in yellowish needles, soluble in alcohol. This also occurs free in the drug, and is poisonous. It is believed that these substances are not active until after oxidation has occurred in the alimentary canal.

Action.—The actions of colchicum, colchicine, and colchiceine differ only in degree.

All the effects are chiefly, and perhaps wholly, referable to local irritation. The skin is somewhat irritated, all mucous membranes powerfully so, sneezing, coughing, running at the eyes and nose being prominent symptoms of exposure to the dust. Its internal effects are very slow in developing, some hours usually elapsing, thus strengthening the theory of preliminary oxidation of the colchicine. Then nausea and pain in the stomach, with lassitude and salivation come on. If the dose is large enough, vomiting and purging follow, and these are characteristic of great irritation, the stools being mucous and perhaps bloody. Varying, and mostly slight, symptoms of reflex stimulation may be observed. In severe poisoning paralysis quickly follows, beginning at the lower extremities, proceeding upward, and killing by asphyxiation. It is generally believed that the latter effects are entirely dependent upon the irritation. Even if given hypodermically, the principle is excreted into the stomach and intestines, and the *modus operandi* is the same. In any case, the practical facts are that the characteristic effects of overdosage are severe abdominal irritation and severe depression, both of which are to be avoided as much as possible in its medicinal employment. The effects upon the kidneys are very irregular, depending apparently upon stimulation by small quantities, depression by larger ones. Lastly it may be noted that the irritant effects of colchicum are cumulative. They may be produced quickly by large doses, or gradually by continued small ones, so that its administration has always to be performed with watchfulness and care.

Treatment of Poisoning.—The use of the stomach pump is indicated, or emetics may be used, *e.g.* ipecacuanha, zinc sulphate, mustard; or apomorphine, administered hypodermically in doses of four or five milligrams. Mucilaginous drinks and abundance of water are beneficial. Tannic acid neutralizes the poison and is an antidote. The bowels should be cleared out by castor oil, while the abdominal pain is quieted by morphine or opium. Heat applied to the extremities and abdomen also relieves pain. For the depression, stimulants should be employed.

Use and Administration.—All the study of the action of colchicum is devoid of therapeutic value, as no relation can be seen between the former and its therapeutic use, which is almost exclusively in the treatment of gout. We only know that gout and all its sequelæ and dependent functional disturbances are markedly relieved by the administration of colchicum, which has for very long been regarded as a specific for that disease. All cases are not equally benefited, acute and the early stages of chronic ones being much more amenable. With long-continued administration, the drug gradually loses its effectiveness, and at the same time undesirable effects become more troublesome. The desirability of cautious administration thus becomes apparent. As soon as abdominal disturbances begin, the administration should be stopped for a while.

The forms of administration are very numerous. The powdered drug is often given in doses of gr. ij.–viii. (0.12–0.5). The Pharmacopœia offers us an extract of the root, dose gr. ss.–ij. (0.03–0.13), fluid extract of the seeds, dose ♏ ij. to viij. (0.13–0.5), a ten-per-cent. tincture of the seeds, average dose ♏ xxx. (2.0), and a ten-per-cent. wine of the seeds, dose the same as of the tincture. The Pharmacopœia requires that the extract contain 1.4 per cent., the fluid extract 0.5 per cent. and the tincture 0.05 per cent of colchicine. Colchicine is frequently given in doses of gr. $\frac{1}{100}$ to $\frac{1}{45}$ (0.0005–0.0022), colchiceine occasionally in maximum doses about half as large. Tannate of colchicine is somewhat used in doses about twice as large as those of colchicine itself. Henry H. Rusby.

**Cold, Physiological Action of.**—This subject is a highly complex one, comprising many phenomena which are sharply individualized, and hence receive consideration under special headings. Thus we may take at random the effects of low temperatures upon the body at large—the so-called "exposure to cold." These comprise vasomotor disturbances in the exposed parts, sense of coldness, "goose skin," shivering and chattering of the teeth, snuffling, etc., etc. These and indeed most of the phenomena due to cold are so well known even to the average layman that according to one authority "anybody may qualify as an expert on the subject." If the degree of exposure is greater or more sustained the unprotected extremities may become frost bitten or necrotic—notably the ears, fingers, and toes.

Or let us consider the physiological action of cold from the viewpoint of hydrotherapeutics. Much of our knowledge of this subject comes from Winter-

nitz, who with his successors has brought to light many phenomena which almost amount to laws in their constancy. These are considered under *Hydrotherapy*. Of great significance is the recognition by Winternitz many years ago that the effects of heat and cold are in many ways identical. Thus if one bathe in very hot water "goose skin" appears, identical with that of exposure to cold.

Another study of wide importance is the effects of draughts of air which chill small areas of integument and produce at times effects all out of proportion to their seeming insignificance.

Of very great importance is subnormal temperature, which requires more study as to its cause. Healthy men, athletes in training, have often been found to have actual collapse temperatures in the morning, which became normal after a few hours. Chilliness and often extreme chills—so-called nervous or non-infectious chills—are oftentimes due to subnormal temperatures.

The algidity which follows traumatic shock, including operative shock, is due to a variety of causes, such as exposure for examination or operation, the evaporation of the ether used, and, chiefly, to the collapse induced by the injury or operation. Hence in such cases the great need of warm thick coverings, hot bottles, etc.

Naturally under some of these circumstances a complex state results—certain factors lower the temperature and the lowered temperature then threatens other changes. In respect to many of these causative factors—such as depress the normal temperature of the healthy—we are in complete ignorance.

Many experiments have been made upon animals and men in which ice has been placed upon or within the body, and both local and general lowering of temperature studied; also the interval required for equilibrium. In another set of facts, experimental or clinical, the temperature required to kill has often been measured, also the temperature at which reanimation is possible, the latter being known as the *critical temperature*. This varies much with the species of animals, etc., its limits being from 18° to 28° C. The lethal, irrecoverable temperature is several degrees lower than the preceding. If we regard the normal critical temperature as 24° C., the lethal will be about 21° C. These temperatures are rectal.

The phenomena of death from exposure to cold may be studied on the animal. If one with normal temperature be placed in ice water, the rectal temperature is seen to fall steadily. At about 28.4° C. (83.1° F.) there is a total failure of function as shown by paralysis and relaxed sphincters. There is a gradual loss of motility and sensibility, of abolition of reflexes, of weakening of heart beat, the pulse becoming slower and irregular. Respiration shows similar changes. The whole picture suggests narcosis. Exposed men, as in the case of soldiers, show diminished sensibility and progressive drowsiness, with tendency to fall into the sleep of death. These men and animals, while they die by the nervous route, are believed by some to perish because of molecular changes in the body cells. As long as the rectal temperature is above the critical point there is a chance for reanimation.

A special type of the effects of cold is seen in the use of antithermics in subjects with high temperatures; these are fully covered elsewhere. The use of carbonic acid snow as a caustic is also discussed in its place.

A particular subject for discussion is the anatomical and physiological results of congelation, which naturally suggest the corresponding chapter in death due to heat. Let us suppose a rabbit chilled to 30° C. only. There is observed a slight diminution of red blood corpuscles and hemoglobin, or at least a disturbance in their contents. This could be explained perhaps by the shock of the cold which drives the blood inward. There is a marked "venosity" of the blood with escape of coloring matters as hemoglobinuria. From the results of similar experiments with animals having biliary fistulæ, it seems that part of the hemoglobin is transformed to bile. But if animals are killed slowly by cold, thus eliminating the element of the sudden shock, the hemoglobinuria never occurs. It has therefore no essential part in death by cold.

As in the case of burns, albuminuria occurs in a large majority of cases. There is no anatomical cause perceptible.

The skin, mucosæ, and musculature are all very pale; lungs congested and edematous; pleuræ and pericardium ecchymotic; heart distended with dark liquid blood; intestinal mucosæ distended with blood; kidneys congested. In cells the supposed disorganization is not sensible to the eye, for their granulation is still normal. There is in fact no true pathology in freezing and the changes may be comprised under physiology.

As the animal is becoming more and more under the influence of cold, approaching a fatal end, all the viscera seem able to execute their functions under stimulation. Even the centers in the medulla are active at the last moment. Not until the cortical and other central cells are paralyzed by the cold does death actually occur, although the animal has been beyond reanimation for a considerable interval.

The subject of vasomotor reflexes generated by cold is so large that not many years ago a great number of diseases were ascribed to it. Experiments of the most numerous and varied kind have thrown but little light on clinical work.

EDWARD PREBLE.

**Cold, Therapeutics of.**—Heat and cold are two relative modes of molecular motion. We call an object warm or cold when it possesses more or less molecular motion than our bodies contain. According to a fundamental law of physics, motion takes place in the line of least resistance, and since a greater quantity of motion offers more resistance than a smaller quantity, it follows that motion, unless impeded, always tends in the direction of lesser motion, or, in other words, from heat toward cold. If the animal body, therefore, comes in contact with a colder medium, it loses a certain amount of its heat; and if the surrounding temperature is sufficiently low and if it remains so for a sufficient length of time, enough heat is extracted to threaten and even to extinguish life. We may hence conclude that while cold acts as an antipyretic, it also acts as a depressant. On the other hand, when cold is applied fugitively, or for a short time, it has a stimulant and tonic effect. This duplex action of cold is demonstrated by the following observations: Liebermeister and Kernig found by actual experiment that brief exposure of healthy persons to cold baths elevates the temperature, while on the clinical side it has been abundantly proven that prolonged exposure of fever patients to cold invariably reduces the temperature.

That a healthy body may have its temperature elevated by transient exposure to cold, and that a fevered body may suffer depression of temperature if exposed to cold, are facts which accord with another physical law, viz., that action and reaction are equal. A healthy body is momentarily thrown out of its accustomed equilibrium by the aggressive force of cold, but in virtue of its greater inherent strength and resistance it is soon enabled to react on and to neutralize the influence of this disturbance, and while undergoing this greater activity its temperature is elevated. On the other hand, the fevered body possesses less resistance and is too feeble to

offer much resistance to the aggressive action of cold, and hence the latter readily depresses the abnormally augmented activity of the body. Cold may, therefore, be an antipyretic or a stimulant according to the circumstances under which it acts; thus showing that, like all our therapeutic agents, its effects are controlled by the dose and by the length of time during which it is administered. Additional cold also contracts and condenses bodily tissue, and thus incidentally it has the power of contracting blood-vessels—a property of considerable therapeutic importance.

Physiologically it may be said then that cold acts (1) as an antipyretic; (2) as a tonic or stimulant; and (3) as a contractor of the blood-vessels, by which means it lessens the supply of blood.

Methods of Applying Cold.—It has already been shown that the effects of cold depend on the manner in which this agent is applied, and it is therefore necessary briefly to consider the different modes of its application together with the physiological effects of each.

*Wet-sheet Application.*—A cotton or linen sheet is wrung out of water having a temperature of 80° or 90° F.; it is then wrapped around the patient's body, and is allowed to remain for two, three, or four minutes. If the patient is in a feeble condition, vigorous friction must precede and follow the application of the sheet. The temperature of the water may be gradually lowered as the patient becomes accustomed to the influence of cold. Used in this way the wet sheet takes the place of a cold bath in a certain class of invalids, relieves fatigue and nerve depression, and invigorates vital energy.

*Spinal Bath.*—Water at a temperature of 80° F. and gradually cooled is poured from a jug or can, or pressed from a large sponge, along the spine as the patient sits on a stool in the bath tub. It is to be continued for from five to ten minutes at a time and may be repeated once or twice every day. In a short time the patient will be able to bear the water entirely cold. The spinal cord, as well as the peripheral and visceral nerves, is stimulated, and it is claimed that the abdominal organs are influenced favorably.

*The Pail Douche.*—This method of bathing consists in throwing three or four bucketfuls of cold water over the front and back of the patient's chest while he is sitting in a bath tub. The exact temperature of the water is to be graduated by the feelings of the patient. A vigorous rubbing with a dry, coarse towel follows the douching. This form of bath is available only for those who possess a rather vigorous constitution, but in such cases it acts as a powerful invigorator.

*The Spray Douche.*—No other form of bathing produces such powerful stimulation as that of the cold spray douche. The effects of the cold are enhanced by the mechanical impact of the water on the body, and they vary, of course, in accordance with the size, force, direction, and duration of the column of water which is employed. The size of the latter may be from one to three inches in diameter and may fall from a distance of from a few to ten or twenty feet; or it may be directed in a small stream at right angles against the patient's body. The stream may also be broken up into fine jets and allowed to fall on the patient's body, or be directed against it at an angle. It may be used alternately with hot or tepid water, and in beginning to use it, in cases in which the power of vital resistance is not very pronounced, it is a good plan to employ water with a temperature of about 80° or 85° F. and gradually lower it to the desired point of coldness. If cold water is used from the outset in the treatment of such persons it is best first to spray the extremities and then the trunk. In persons possessed of robust reaction the spray should be allowed to fall from the desired height on the head, shoulders, and back, and should be continued for from one to three minutes. It is important that it should not be continued for too long a time, for if it is, the patient will fail to obtain its full exhilarating property.

*The Plunge Bath.*—In this form of bathing the person jumps into a pool or tub of cold water, remains there for a few minutes, and is then dried and rubbed with towels. The effects of such a bath are similar to those of the douche, although not so pronounced. The plunge bath is the final stage of the Turkish bath, and to it the latter owes much of its agreeable and stimulating property. As in the douche, a sudden chilliness, a deep inspiration, and a roughening of the skin are some of its prominent effects, which in a few minutes are followed by a sense of warmth and exhilaration.

*The Prolonged Bath.*—Here the patient is immersed in a tub of water the temperature of which ranges from 65° to 70° F., or slightly lower. It abstracts heat in febrile diseases, soothes the irritable nervous system, and provokes sleep. The duration of a bath of this kind is governed by the influence which it exerts on the fever. This is its chief object. If the fever falls to the level of 102° F., or still nearer the normal, the bath is discontinued and the patient is returned to bed. This method of treating fever was introduced by Currie and Brand about a century ago, but fell into disuse some time later. It was revived by Liebermeister, von Ziemssen, and others in Germany, and has latterly found strong advocates in America. among whom are Wilson, Tyson, and Baruch.

*Ice Applications.*—The application of ice to the human body is the most concentrated form in which cold may be employed. Its physiological action, which differs somewhat from that of the other forms already described, has been investigated by various observers. Thus, Mosler found that by applying an ice bag over the spleen of a dog its length diminished from 17 to 14 centimeters, and its breadth from 5 to 4.6 centimeters in the course of an hour. Schlikoff made a series of observations on man, in the course of which the thermometer was introduced into various cavities of the human body, and ice bags were applied to the exterior. For example: (1) A thermometer being placed between the gum and the cheek, and an ice bag applied to the outside, the temperature fell 5.1° C. in one hour. After removing the ice bag, the temperature returned to the normal in half an hour's time. (2) When the thermometer was held in the hollow of the hand, and an ice bag applied to its dorsum, in seventy minutes the temperature fell 5.8° C.; an hour after the removal of the ice bag the temperature had not attained its original elevation. (3) In an empyemic patient the thermometer was introduced into the pleural cavity firmly against its inner wall, and the ice bag was placed immediately over it; in an hour the temperature fell 3.7° C. The original temperature was regained in fifty minutes after the thermometer was removed. The thickness of the thoracic wall was 3.2 centimeters, which gives the distance between the bulb of the thermometer and the ice bag. (4) Introduction of a thermometer into the intestine through an intestinal fistula, and the application of an ice bag over the abdomen reduced the temperature 2.3° C. in the course of half an hour—the distance between the thermometer bulb and the ice bag having been about 4 centimeters. (5) When the thermometer was placed in the vagina, and the ice bag over the pubic arch—the distance between the two being 7 centimeters—the temperature fell nearly 1° C. in a little less than an hour and a half. (6) Introducing a thermometer into a fistulous passage leading to a carious tibia—the soft parts being inflamed, thickened, and edematous—and placing an ice bag over the same, reduced the temperature 0.5° C. in eighty

minutes. The distance between the thermometer and the ice was about 4 centimeters.

These experiments demonstrate, therefore, that when cold is employed in the manner indicated it has the property of diminishing the volume of bodily organs, reducing temperature very actively, and showing sufficient penetrating power to influence deep-seated organs.

The Therapeutic Application of Cold.—Next in order will be considered the various affections in which the remedial value of cold is indicated.

*Nervous Debility.*—In cases of nerve exhaustion without serious change in any of the vital organs—a condition often found among men of intellectual pursuits—the douche applied daily is a most valuable adjunct in the treatment. If possible the douche should be commenced during warm weather, and after being begun it should be used every day throughout the year.

*Hemorrhoids.*—When ice in a bag or wrapped in a towel is applied in the early stage of this affection it will give relief quickly. When the disorder is of several days' standing, moist heat is probably preferable; although it is a good plan to test the influence of cold first.

*Acute Orchitis.*—Surrounding the inflamed testicle with ice bags, or allowing a stream of ice water to flow on it, will frequently cut short the pain and relieve the swelling.

*Acute Tonsillitis, Diphtheria, and Croup.*—Application of cold to the neck in these diseases, either in the form of ice bags or in that of compresses, preferably the former, has a most comforting and quieting influence on the patient. It allays fever and pain, and prevents infiltration of the cervical glands.

*Measles.*—In strange contrast to the medical teaching of half a century ago, that patients suffering from measles should be kept in a warm room, remain unwashed, and be protected from all cold air draughts, it is now a well-established fact that the application of cold externally in one form or another, and the administration of an abundant supply of cold water internally, is a most serviceable method of treating this disease. When the fever is mild, sponging of the whole body with cool water will suffice to reduce the temperature. If the fever rises to 103° or 104° F., the cold pack is to be applied, or the patient is to be tubbed. In case there is swelling of the glands of the neck, as often occurs, the application of an ice bag over the tumefaction will have a counteracting effect.

*Scarlatina.*—No other exanthematous disease is so prone to develop a high temperature as scarlet fever, and in no other are the remedial effects of cold applied externally more marked. In mild cases cold sponging is all that is necessary. When the temperature rises to 105° or 106° F., and is accompanied by stupor and delirium, when the rash is dark and not well marked, and when the urine is loaded with albumin, nothing seems to be more effective in reducing fever, in quieting stupor and delirium, and in bringing out a well-marked eruption than a cold tub bath or the cold pack. For the throat affection the ice bag is to be applied externally to the neck, from the beginning of the attack, and the patient is to be encouraged in holding small pieces of ice in the mouth until they are dissolved. Cold water is to be allowed as a drink.

*Cholera Infantum.*—In affections of this kind, when the diarrhea becomes an almost continuous serous discharge, when the abdomen and head are very hot and the extremities are cold, coupled with a tendency to coma, an ice bag or two applied to both the abdomen and the head, and hot-water bags or hot poultices to the arms and legs, are frequently followed by the very best results.

*Cerebral Congestion and Cerebrospinal Meningitis.*—In these diseases the application of a number of ice bags to the head and neck is a most useful therapeutic measure. The action of the cold thus employed is enhanced by the application of mustard or hot water to the extremities.

*Sun-stroke; Heat-stroke.*—The former is merely an intensified form of the latter, and both conditions require the same treatment. The patient should be stripped, laid on a canvas cot, covered with a sheet, and a stream of iced cold water allowed to play on his whole body, while at the same time the head is packed in ice. The stream of water may come from a hose or from the mouth of a large can. When the high temperature is reduced and approaches the normal point, the body should be wrapped in warmed woolen blankets, while the application of cold to the head is to be continued.

*Typhoid Fever.*—The use of cold in various forms and at different temperatures is one of the most approved methods of combating typhoid fever. In mild cases of this disease, or in cases in which the general tub bath is not well borne, frequent or almost constant sponging of the whole body with cool or cold water, slightly acidulated with vinegar, is usually sufficient to restrain the temperature and to reduce it to a proper point. In case the fever makes a stubborn resistance the patient should be placed in a tub bath the temperature of which may range from 60° to 80° F. If it is well borne, it is best to begin with a bath temperature of 65° or 68° F. Sometimes it is a good plan to begin with a bath temperature of 80° and gradually lower it to 60° by the addition of ice water. The patient should remain in the bath for five, ten, or twenty minutes, or longer if necessary, to reduce the fever to 102° F.; and the bath is to be repeated as often as the temperature rises above the latter point. Between the baths ice bags should be used over the abdomen and head, and in cases of intestinal hemorrhage or of marked tympanites the ice bags should be applied continuously to the abdomen. Placing an ice bag over the region of the heart also serves to allay the irritability of that organ. In cases in which tubbing is inexpedient and the temperature remains high the cold pack may be resorted to, or the patient's body may be rubbed with small lumps of ice. After the patient leaves the bath his body must be rubbed dry and wrapped in a warmed blanket in order to secure good bodily reaction.

Cold water should also be freely used internally. This is of great importance. It should be given systematically whether the patient asks for it or not.

*Appendicitis.*—Application of the ice bag over the right iliac fossa is a useful measure to afford relief in this affection. It is superior to the hot poultice, although in some instances the alternate application of the two is beneficial. When vomiting is present the patient should be allowed to dissolve small pieces of ice in his mouth.

*Acute Rheumatism.*—Professor Esmarch, of Kiel, as far back as 1861, drew attention to the great utility of ice locally applied to the involved joints in the treatment of acute articular rheumatism. The results, as compared with those derived from the application of heat, blankets, blisters, etc., were most striking in regard to both the shortening of the attacks and the diminution of the pain. Dr. Wilson Fox reported two cases of rheumatic fever in adults, one with a temperature of 110° F. and the other with a temperature of 107° F., which were treated with cold applications and both made prompt recoveries. The ice was placed on the chest, abdomen, and along the spinal column, and iced water was rapidly poured over the patients' bodies at the same time.

From all the practical evidence at our command there is no more reason why cold should be contraindicated in acute rheumatism than it is in any other acute inflammatory disease; and the day is not far distant when it will be employed as frequently in this disease as it is now used in typhoid fever.

*Acute Pneumonia.*—The principal indications in

the treatment of acute pneumonia are: (1) reduction of the volume of blood in the lungs, (2) reduction of fever, and (3) support of the function of the heart. From his own experience, the author believes that all these indications are fully met by the application of ice to the chest immediately over the seat of inflammation in both croupous and acute catarrhal pneumonia, and that this agent checks the extension of the inflammatory process, constricts the pulmonary capillaries, promotes resolution, disperses the products of exudation, reduces fever, strengthens the pulse, alleviates difficult breathing, abates pain in the chest, and gives general comfort to the patient.

The number of ice bags which are to be applied in any case depends on the degree of fever which is present and on the size of the area which is inflamed. If the fever is not very high and the inflamed area small, one or two bags will answer. If the fever is high and the involved area large, as many as eight or ten may be applied, it being always borne in mind that the head should monopolize one or two constantly. The length of time during which they are kept on also depends somewhat on the range of fever. If the temperature falls near the normal it is good policy to remove some, but not all, of the ice bags, unless the crisis is at hand. If they should be removed too early and before the crisis-period, the temperature will rise again, and as a rule it is brought down with greater difficulty the second than the first time.

The foregoing conclusions on the efficiency of ice applications in acute pneumonia are based on 400 cases of this disease which were treated according to this method, and which were collected from the practice of fellow practitioners, and from that of the writer, out of which seventeen, or 4.25 per cent., died.

In making a comparative estimate concerning the intrinsic worth of any treatment of pneumonia, it must be borne in mind that according to the expectant plan of treating pneumonia, which was practised on a large scale in Vienna hospitals fifty or sixty years ago, and in which neither internal nor external treatment was administered, eighty-five to ninety per cent. of the patients recovered. This clearly shows not only a strong natural tendency toward recovery in this disease, but also that any plan of treatment which fails to reduce the death rate below tent or twelve per cent. is valueless.

*Acute Pleurisy.*—There is no other external application that will relieve the painful breathing of acute pleurisy more quickly than that of the ice bag; and when this is coupled with suitable internal treatment it will soon cut short the disease.

*Acute Pericarditis.*—In this affection the ice bag, when applied directly over the heart, gives relief to the pain, reduces fever, and quiets the action of the heart.

*Hemoptysis.*—Whether hemoptysis is of pulmonary or of cardiac origin, it is always benefited by the application of one or two ice bags to the chest. It is important, of course, that a differential diagnosis in regard to the source of the bleeding should be made as soon as possible, so that each case may be treated with appropriate internal remedies in connection with the external use of ice.

*Pulmonary Phthisis.*—The cold douche has been used in Germany and in this country in the treatment of this disease, and is highly recommended in cases in which the temperature of the body is at or very near the normal point. The patient, previous to the bathing, is rubbed with a dry coarse towel, and is then exposed to the douche for ten or fifteen seconds, or even longer, after which he is again rubbed until the skin becomes red. He is then allowed to take a brisk walk for a short period, after which he takes a rest. This is repeated every day. In cases of acute phthisis one or two ice bags should be applied over the affected area and retained there. It is very good practice to allow phthisical patients with irritable hearts to wear an ice bag continually over the cardiac area. It quiets the heart and checks the temperature.

THOMAS J. MAYS.

**Coleoptera.**—The beetles, an order of insects which have the front wings modified to form hard elytra which serve as covers for the hind wings. The blister-beetles, family *Meloidæ*, are of interest on account of the vesicant properties of their secretions. See *Insects, poisonous.* A. S. P.

**Colic.**—(From κωλικός, relating to the colon.) This is a condition characterized by pain of a peculiarly intense paroxysmal type produced either directly or indirectly by the spasmodic contraction of one of the hollow abdominal viscera having non-striated muscle walls and covered entirely or in part by peritoneum or in close relation with it. Shiel contends that colic occurs only in organs in close relation with the peritoneum and that the cause of the excruciating type of pain at the time of an attack is due to the fact that the nerves governing the pain sense in the intestine travel to their terminal destination along the peritoneum, the pain being produced in the peritoneal coat. Kast and Meltzer have shown, however, that the intestines themselves are sensitive to pain. Kemp defines colic as the painful stimulation of the intestinal nerves produced by tonic contractions of the intestines.

Ordinarily, when we speak of colic, we mean the condition as produced in the intestines, commonly called enteralgia, but there exist other forms named according to the organ which may be the cause of the condition. Authorities recognize three main forms as intestinal, hepatic, and renal, and several other forms as produced reflexly from a diseased condition of any organ in the abdomen and also of the vertebræ. Among the forms produced reflexly are classed ovarian, uterine, and appendical colic. Lead and infantile colic will be considered as forms of intestinal colic.

GENERAL SYMPTOMS.—All the forms of colic, having the same basic cause for the production of pain, namely, the spasmodic contraction of a hollow viscus, have certain symptoms in common which may vary in kind and degree and be characterized by more or less fluctuation and periodicity in the attack, which may last but a few minutes or be a matter of hours or days, occurring intermittently or remittently as in appendical or renal colic. The cardinal symptom is the pain, peculiar in its type, acute, usually coming on suddenly and disappearing as suddenly, or in mild cases having a gradual onset and wearing off in the same manner. It increases in intensity, reaches a climax then subsides and even in mild cases is severe. The attacks are paroxysmal and in the graver cases the pain is so excruciating as to produce faintness and collapse; but a striking feature seems to be that a few minutes or hours after an attack of any form of colic the patient may be apparently in a normal condition so far as the effects of the colic are concerned. Nausea, vomiting, and tenesmus may be caused by the severity of the pain. The pulse is rapid and feeble, sometimes irregular in severe cases, but rarely exceeds 100 and occasionally may be slower than normal. The temperature depends upon the condition causing the colic and will be considered under the different forms of colic. The attitude of the patient is characteristic. The expression is anxious, the face is pale and bathed in sweat, the body is bent so that the chest and shoulders are drawn toward the knees, and the abdomen is grasped and pressed by both hands—deeply in the case of intestinal colic—in the effort to allay the suffering. The abdominal muscles are rigid, nature's effort to protect the parts. If the patient

is recumbent, the legs are flexed on the abdomen in order to relieve the tension of the abdominal muscles. Gouty and rheumatic persons seem to exhibit a more marked tendency to the various forms of colic, with possibly the exception of the appendical form.

Pathology.—This depends upon the seat and cause of the trouble. The only condition produced by the colic seems to be a slight hyperesthesia and congestion, but there may be distinct pathological changes in the organ which is the seat of the trouble. The conditions to be expected in each form will now be considered under the different types.

Intestinal colic or enteralgia is by far the most common form and is caused by the sudden distention of some part of the intestine, more often the large intestine, by an accumulation of gas producing flatulence or by the spasmodic effort of the intestine to rid itself of some irritant other than gas.

*Symptoms.*—The pain is located around the umbilicus but travels along the intestine toward the rectum and is relieved upon the expulsion of the accumulated gas or the irritating cause. It is described as boring, tearing, or twisting in character, and is severe, coming on in paroxysms and ofttimes causing collapse. Unlike the other forms, intestinal colic is rarely accompanied by elevation of temperature, and if there is any deviation from the normal, it may be to a slight degree subnormal. In the cases in which flatulence gives rise to colic, the abdomen is distended and in thin subjects the outline of the intestines can be defined. Borborygmus may be present. In the form where but little or no gas is present, distention is absent and the intestines can be seen formed into knots, which under the hand give a sensation of hardness.

*Causes.*—Bayliss and Starling have shown that irritation of any part of the gut leads to contraction above and inhibition below, causing a wave-like motion having the purpose of removing the source of irritation and that these excessive intestinal contractions are the cause of colic. The contributing causes are many but Boas considers constipation to be the chief and most constant one. As constipation is the result of numerous other pathological or abnormal conditions, one is compelled to look for the causes of the second condition before reaching the cause of the colic. Causes in general for intestinal colic may be divided into two main groups, external and internal, but this division is really but a rough one. Under external may be classed the following: sudden changes in temperature affecting the body temperature; indigestible foods causing acute indigestion; certain constituents of foods for which there may be an idiosyncrasy, such as an excess of carbohydrates; worms; gallstones; mechanical conditions of other abdominal organs such as gastroptosis and floating kidney; purgatives; and occasionally the presence of foreign bodies which have been swallowed gives rise to colic.

Among the internal causes are found such as are productive of constitutional conditions and organic and structural changes of the intestines. These are gout and rheumatism; alcholism; locomotor ataxia, in which condition colic occurs as a crisis; mineral poisoning, the chief of which are lead and copper poisoning; mucous colitis, diarrhea, and constipation; structural alterations in the intestines, such as enteroptosis, intestinal obstruction, appendicitis, and hernia. In many cases an unrecognized hernia, in which there is but a slight pinching of the gut in the internal abdominal ring, gives rise to severe colicky conditions. Enteralgia may be produced by any of the neuroses, such as insanity and hysteria. It is interesting to find that the so-called internal conditions are the ones more often productive of the chief cause of colic, constipation. They are the slower chronic conditions which give rise to excessive nervous irritability and some forms of the neuroses which in turn influence the functions of the intestines producing chronic indigestion, constipation, and the resultant colic. Not only is the nerve force affected but the musculature of the bowel in time suffers, losing its tonic condition. Intestinal colic is more common in women and children than in men, especially in women of the neurotic type.

*Lead colic* is one of the symptoms of lead poisoning and usually accompanies the constipation caused by the gradual absorption of lead into the system. The colic is of the intestinal type and the abdomen instead of being distended assumes a scaphoid shape with rigid abdominal muscles. The recurrent attacks of colic and constipation may be one of the first signs of lead poisoning and when found accompanied by a slow, hard pulse, blue lines on the gums, wrist-drop, and anemia no doubt is felt as to the cause of the colic. It is found among people who work in lead—painters, plumbers, and pipe workers, and has been known to be caused by the use of hair dyes and of lead in medicinal form.

Infantile colic is the form found in infants and young children and until recent years, when milk modification has corrected many of the infantile conditions, was considered an almost constant accompaniment of babyhood.

The *symptoms* are about the same as those of colic in the adult. The patient is restless, cannot sleep, and breaks out in paroxysms of hard crying which do not cease until the pain is over. The little knees are drawn up to the abdomen, the hands are clenched, and the face is drawn and pale, plainly showing the intense suffering the child is enduring. The abdomen is distended and under the hand the intestine can be palpated. The extremities are cold, the pulse is rapid, and after a hard attack the child is exhausted. There is rarely any elevation of temperature, but it may become subnormal in cases where the constitution has been weakened by previous disease.

*Causes.*—Some fault in the proportions of the constituents of the food producing either acute or chronic indigestion is the commonest cause of this trouble in infancy and early childhood. In older children the too early attempt to eat the indigestible vegetables without a sufficient amount of mastication is a frequent cause. Colic may accompany or be a symptom of any of the diseases of childhood, in which case it is produced by the weakened muscular condition of the intestinal walls. As in adults, so in children, it is a common symptom of appendicitis and renal calculi. Biliary colic rarely or never occurs in children. Breast-fed as well as artificially fed babies may be addicted to it. Children who have been the subjects of malnutrition are more prone to attacks of colic, due probably to the weakened intestines which in some cases never regain their normal tone. Occasionally, the too quick taking of food in bottle-fed babies, because of a large opening in the rubber nipple and the sudden inpouring of a quantity of liquid into the stomach may induce an attack of colic. Changes in temperature with exposure of the legs and feet to cold is a frequent cause. According to Still, mucous colitis and also worms are productive of this condition, but he considers that the worms themselves do not induce colic; instead they create an abnormal secretion of mucus which in turn stimulates peristalsis with the resultant colic. Constipation is an important factor in the production of colic in young children, and careful examination of the stools will provide a sure indication in most cases as to the cause of the condition. Notwithstanding statements to the contrary, attacks of colic often occur during the eruption of the first or temporary teeth. The attacks come on as the teeth erupt and may be repeated for several days after the teeth are through the gums. This occurs more frequently in children who are weakened through other diseased conditions, but teething is certainly a cause of colic.

Hepatic or biliary colic is produced by the effort of a gallstone to pass from the gall-bladder into the bile duct and on to the duodenum and is a symptom of cholelithiasis. The attack usually comes on suddenly, creating a sharp excruciating pain in the right hypochondriac region, extending upward toward the shoulder—never downward—parallel with the spine. Chills and fever, vomiting, with coldness of the extremities, sweating, hiccoughs, and partial or complete collapse usually characterize the typical attack. The temperature may be subnormal or reach 102°–103°. Mild attacks do not always give the characteristic shooting pain upward toward the shoulder, especially those accompanying a mild gall-bladder condition, where only gravel is present, but induce an extreme soreness or tenderness referred to the back about two inches below the inferior angle of the scapula. This tenderness may be persistent, occurring not only during an attack but in a less degree in the interim, causing the patient to become nervous and irritable. Jaundice is usually present about twelve hours after an attack.

The *symptoms* may vary according to the position of the stone. Savill makes the following distinctions: a stone which is impacted in the common duct creates biliary colic, marked jaundice and a dis tended gall-bladder with an enlarged liver if the impaction continues. A stone impacted in the neck of the gall-bladder—the cystic duct—causes biliary colic without jaundice and ultimately the bladder may become distended forming a tumor. A stone impacted in the hepatic duct is rare, but when it occurs causes colic and jaundice with bladder distention. Stones may form in the radicles of the hepatic duct and give rise to indefinite symptoms sometimes without pain but they usually cause no symptoms. Occasionally biliary sand or cholesterin in the gall-bladder causes recurring paroxysms of pain unaccompanied by jaundice or the usual symptoms. The true condition defies diagnosis.

Renal or kidney colic is the form of colic produced by the attempted passage of a renal calculus, in the form of either a stone or gravel, from the pelvis of the kidney through the lumen of the ureter to the bladder. It is one of the expected symptoms of nephrolithiasis.

*Symptoms.*—The pain which is usually intense extend from the region of the kidney downward along the loin following the direction of the ureter to the bladder, causing in some cases retraction of the testicle. It may be located on either side of the abdomen, depending on which kidney is the seat of the stone. One of the chief diagnostic features of the pain is its direction, which is always downward, thus helping to distinguish this form of colic from the other types. Suffering is severe and may be extended intermittently over days, depending on the renewed efforts of the ureter to advance the stone or the attempt of gravel to follow in the wake of a stone. When the stone or calculus reaches the bladder, the pain ceases unless a cystitis is set up, but soreness along the path of the expelled stone may be felt for several days. As in the other forms of colic, nausea and vomiting, pallor, and cold extremities, together with collapse and strangury or frequent micturition are present. The temperature is rarely elevated unless severe complications present themselves. The urine will be found to contain small crystals, blood, and pus cells, and the type of crystal found assists in the diagnosis of the kind of calculus causing the colic. Occasionally a movable kidney will give rise to all the symptoms of colic, due many times to a twist in the ureter. When this occurs the urine is free from the exudates found when the condition is caused by gravel or a calculus. Renal colic occurs more frequently in men and children than in women, especially men past the meridian of life. One could almost say it was a condition of extreme youth and advancing age.

Appendical colic is often the initial symptom of appendicitis and is caused by a pathological condition of the appendix. It takes the form of intestinal colic, the pain radiating around the umbilicus and in the majority of cases finally referring itself to the right inguinal region, but occasionally in children where the appendix is long, it may be referred to the left inguinal region.

*Symptoms.*—It has all the symptoms of intestinal colic and in addition is accompanied by tenderness in the region of McBurney's point—midway between the umbilicus and the anterior superior iliac spine—with rigidity of the right rectus muscle and an indefinite tumor in the same region. The temperature may rise to 102°–104°, the pulse is thready and rapid, nausea and vomiting with constipation occur. In this form of colic there is little or no flatulence so that the pain is not relieved by the expulsion of gas, but is supposed to be due to the effort of the appendix to force mucus through its almost occluded lumen.

All ages are subject to appendical colic but it is most frequently found in the young and rarely occurs after middle life. Deaver states that "all cases of abdominal trouble in children are appendicitis until proved otherwise."

Pancreatic colic is the pain produced by a diseased condition of the pancreas, and compared with the other forms of colic is comparatively rare. This may be due to the fact that the importance of the pancreas in the process of digestion has not yet been fully worked out and that lesions of the former are in most cases accompanied by diseased conditions in surrounding organs.

*Symptoms.*—The pain is most frequently located in the epigastrium, but may radiate downward in the abdomen. It is paroxysmal in type, coming on suddenly, and intense in character. It has been known to radiate upward toward the shoulder on either the right or left side, and along the region of the pancreas there are tenderness and soreness. The most diagnostic point of tenderness is a spot known as "Robson's point," which is located just above and to the right of the umbilicus. There may be rigidity of the recti muscles, together with all the general symptoms of intestinal colic. Conditions in the pancreas are usually accompanied by gall-bladder conditions, so that symptoms referable to both organs may be present in pancreatic affections producing colic.

Uterine and ovarian colic may be produced reflexly by any abnormal condition in the pelvis affecting the uterus and ovaries.

*Symptoms.*—In some women, the only sign of the approach of the menstrual flow each month is the sensation of a slight colicky pain referred to the epigastrium and moving along the intestine, increasing somewhat in intensity and wearing away as the flow increases. The pain is paroxysmal and in nervous women may be so severe as to produce hysterics and fainting. All the symptoms of intestinal colic may be experienced, together with bearing down pains in the pelvis, as in dysmenorrhea in which condition it is caused by the effort of the uterus to contract and expel the blood. As soon as this is done, the pain ceases only to be renewed at the next effort of the uterus to empty itself before the cervix is sufficiently relaxed. When this occurs and the equilibrium is restored, the flow continues without the colicky pain. Neuralgia of any of the pelvic organs may induce colic reflexly. It is much more common in young girls and married women who have never borne children and in whom the pelvic organs have remained undeveloped.

General Treatment.—All the forms of colic, having the same cardinal symptom, pain, can usually be relieved by a general form of treatment, after which the cause should be treated and removed if possible.

Heat is the quickest and most easily procured means and should be applied to the abdomen and feet in the form of dry heat as hot-water bottles, hot bags of salt, or a heated flat-iron covered with a towel or flannel to protect the parts; or moist heat in the form of poultices or stupes may be placed over the seat of the pain. Flannel wrung out of water as hot as can be borne and sprinkled with turpentine, is the popular stupe employed. Hot baths often prove efficacious. In the severe cases, especially where the patient is neurotic, opium may be resorted to. For this, morphine, gr. $\frac{1}{8}$ to $\frac{1}{4}$ and atropine, gr. $\frac{1}{100}$, or codeine, the same amount as the morphine, should be given hypodermically. When the vomiting has ceased or has not been present, a sedative such as chloral or the bromides may be administered, or in a case of vomiting and excessive pain a few whiffs of chloroform may be necessary. After the attack, calomel, gr. ii to v, followed in a few hours by a brisk purge, as Epsom salts, is usually indicated. Among the other drugs giving relief in colic may be mentioned Squibb's mixture, compound cardamom tincture, brandy, oil of peppermint, peppermint water, other forms of opium, such as laudanum (tinctura opii) or paregoric (tinctura opii camphorata), and spirit of camphor. Intestinal colic in addition to the above-mentioned remedies may be greatly relieved by a high colon flushing of warm soapsuds water to which has been added warm olive oil, one-half pint to the quart of water. Two to three ounces of warm olive oil per rectum, or simply a flushing of warm water may be sufficient to remove both the pain and the cause. Spirit of camphor, five to twenty minims, or fluid extract of ginger, ten to thirty minims in a teaspoonful of hot water, is a convenient means of affording quick relief. Kemp employes tincture of belladonna with good results.

Infantile colic is so commonly met with in general practice that a routine treatment may prove of service. Often simply turning the infant on its stomach and gently massaging the abdomen causes removal of the flatus. If the pain persists a colon flushing of warm saline solution, or warm water alone, or one to two ounces of olive oil warmed may be tried. Heat must be applied to the feet in all cases of colic in children. Most households usually contain the simple drugs such as peppermint water, of which one-half teaspoonful in a teaspoonful of hot water, or brandy, five to ten minims to a teaspoonful of hot water, or spirit of camphor, one to three minims in hot water, may be employed by mouth. If further medication is necessary, the following prescription will prove of service:

| | |
|---|---|
| Chlorali hydratis | gr. viii. |
| Sodii citratis | gr. xvi. |
| Tinct. cardamomi compositæ | ♏ vm-x. |
| Aquæ menthæ piperitæ | ℥ ss. |
| Aquæ ..... q. s. ad | ℥ ij |

Misce et signa.—One teaspoonful to be given in a tablespoonful of hot water every two hours for three doses.

Food correction and careful clothing of an infant according to the variations of weather will usually prove decided preventives, unless the acute colic condition has a distinct pathological basis, which may need special treatment. Opium is contraindicated in infantile and appendical colic for the reason that it masks the symptoms. In some instances, however, it may be necessary to employ a form of opium, in which case paregoric, ten to thirty minims, or laudanum, three to ten minims, may be used in infantile cases. Codeine, $\frac{1}{16}$ to $\frac{1}{4}$ gr., is safer in the treatment of children and may be given by mouth or hypodermically.

In the severe forms of colic, rest in bed, liquid diet, and a careful attention to the rules of hygiene, together with special treatment of the underlying cause, is absolutely necessary to secure beneficial and lasting results.

In addition to numerous articles on the subject, the works of Thomas Dixon Savill and George Frederic Still of London, Robert Coleman Kemp of New York, and James Tyson of Philadelphia, together with an article by Dr. Shiels of New York published in the *American Journal of Surgery*, for April, 1908, have been consulted. ESTHER L. JEFFERIS.

**Colitis.**—It is not quite easy to determine just what lesions are to be classed under this heading. All those infectious or toxic lesions which lead to ulcerative or otherwise destructive processes in the colon, or to hemorrhages, are to be excluded, as well as parasitic disease and those secondary inflammatory or phlegmonous processes caused by neoplasms or disturbances of the blood supply. Aside from these, on the whole rather sharply defined and more or less readily distinguishable groups of colonic disease, the term colitis is often rather loosely applied, and in the absence of well-marked and generally recognized clinical pictures, there is still much discussion as to the etiology, pathology, and treatment of what may correctly be termed colitis. Within the limitations just laid down, simple colitis may be considered as one of the large group of catarrhal diseases. Nothnagel, in his classical treatise,[1] does not, however, treat colitis separately, but discusses it, together with catarrh of the ileum and jejunum, as a phase of acute and chronic general enteritis. In this country, and especially within the last few years, colitis has become quite a favorite diagnosis, and very frequently on quite insufficient grounds. It is too frequently associated with such vague terms as "intestinal fermentation;" the main pathognomonic symptom on which the diagnosis is supposed to rest being the actual or fancied excess of indican in the urine. There are, however, sufficiently well-marked signs, both pathological and clinical, which permit an accurate diagnosis of colitis. Like all other catarrhal diseases, colitis may be subdivided into an acute and a chronic state.

ACUTE COLITIS.—This occurs either as an integral part of a general intestinal or gastrointestinal catarrh, or, and this happens very often, the catarrhal process is limited strictly to the colon. Again the entire colon may be involved, or only certain portions of it.

*Etiology.*—There are numerous factors that may be concerned in the etiology of this disease. There are, for instance, various toxic substances, which can find their way to the colon by the route of the stomach and the small intestines. The peristalsis in the large gut is naturally slower than in the small intestines; hence the toxic material stays longer in the colon, and for this reason, and because the physiological putrefaction is at its height here, catarrhal irritation is easily produced. In much the same way, constipation participates largely in causing acute colitis. By the mere mechanical action of the more or less hard scybala, abrasions of the protecting epithelium are brought about, thus facilitating the absorption of toxic material and infections with coli bacilli and other microbes. As another etiological factor, there are the infections, pure and simple, more particularly those with the bacilli of the coli group. These infections rarely come from outside of the colon, but most frequently originate from the normal flora of the colon, which from one cause or another has become pathogenic and virulent.

*Pathology.*—Our knowledge of the pathology of acute colitis is still extremely unsatisfactory. People do not die of this disease, and our scanty information concerning the characteristic structural changes is obtained from autopsies on subjects dead of other diseases, or from operations on patients who happened to have their colon in a condition of acute catarrh. It may be said that the mucous membrane is more or less congested, either uniformly or in patches, and perhaps somewhat edematous. Mucus, though it may appear in varying quantities, is never absent,

and in fact, is the one most characteristic sign. It is often mixed intimately with the fecal matter. This is especially the case when the colitis forms part of a general enteritis. In pure colitis, the mucus usually covers portions of the free surface of the mucosa. It is either glairy and tenacious, or more turbid and thin. In acute catarrh, the mucus is seldom seen in the form of membranes, or as ropes and strings. The turbidity is due to the plentiful admixture of epithelial cells. It is well known that even under normal conditions, great quantities of epithelial cells are discharged from the colon. When there is catarrh the desquamation of epithelium is increased enormously. If the catarrhal irritation is very severe, small extravasations of blood are often seen. These may lead to small and usually superficial ulcers, at times even to minute abscesses.

The feces may be soft, semi-solid, or fluid or even watery. This last generally, when the small intestines are also involved. The reaction is either alkaline as in the normal, or it is acid. Acidity of the feces is usually associated with gastric hyperacidity, and suggests the upper gastrointestinal tract as the primary seat of the catarrhal irritation. In simple acute colitis, the digestion of the various food-stuffs and tissues, as shown by the chemical and microscopical analysis of the feces, is, as a rule, fairly normal. Blood is rarely seen, and then only in faint traces. Gas bubbles, intimately mixed with the feces, are not uncommon.

*Symptoms.*—The clinical symptoms vary. Acute colitis is not, as a rule, a very serious malady, and often runs its course without the need of a physician. Griping pain is not unusual, but may also be absent. There is more or less diarrhea, or diarrhea alternating with constipation. The temperature is usually normal, but there may be a slight rise. It is extremely rare that the temperature rises to 103° or 104°. In sharp contradistinction to acute catarrhal affections of the small intestine, simple acute colitis does not generally affect the kidneys, and the urine is usually normal. An excess of indican may be present, but is just as frequently absent. Sometimes, however, a very slight and transitory albuminuria, accompanied by a few hyaline and finely granular casts, does occur. It is not generally known, but is nevertheless an assured fact, that in acute colitis, as well as in acute gastrointestinal catarrh, the spleen is nearly always enlarged and palpable. It is important to remember this, for very often a palpable spleen, a slight rise in temperature, diarrhea, and perhaps some tenderness in the region of the caput coli have given rise to a strong suspicion of incipient typhoid fever, and caused much unnecessary alarm and worry.

With sufficient practice, it is possible, with comparatively few exceptions, to palpate with a fair amount of accuracy, the entire colon. This palpation is difficult or impossible in cases of great obesity or of ascites, and in such persons as are unable to relax their abdominal muscles under any conditions. By means of this method of palpation, wherever practicable, many of the morbid changes in the colon, changes in regard to position, mobility, size and thickness, can be recognized. In acute colitis, the colon is often, but by no means always, found tender to pressure, either in its entire length, or only in certain places. The favorite localizations for this tenderness are the caput coli, the hepatic flexure, and above all, the sigmoid flexure. This tenderness is not usually very severe, and disappears together with the other catarrhal symptoms. Considerable gas distention and gas colic may also accompany this form of colitis, but is not a constant symptom. Taken all together, though not any one of the symptoms is either pathognomonic or constant, the diagnosis should not be difficult.

*Treatment.*—This is very simple. The first and principal indication is a thorough cleaning out of the intestine, for the removal of all putrid and toxic material. This is best accomplished by calomel. After that, a moderate dose of salicylate of bismuth (0.5 t.i.d.); an occasional dose of codeine or dionin in case of pain; magnesia usta if the feces are acid. In case of constipation, after the first purging, colonic irrigations of saline solution are indicated. Perhaps also a dose of Pluto water in the morning. The diet should be bland, non-irritating, and of such a nature as to be largely absorbed in the stomach and uppermost intestinal tract, leaving as little residue as possible for the colon. (For example, broths, the whites of eggs, cereals with cream and some sugar, scraped meat, or chicken finely cut and thoroughly masticated.)

Chronic Colitis.—This is of rather more importance than the acute form. It is not only very much more common, but in its beginnings more insidious, and in its consequences more far-reaching. The earliest signs of chronic colitis are seldom recognized, and very often not recognizable. With the possible exception of some slight discomforts, too insignificant to be brought to the notice of the physician, the patient is not aware of any abnormal process going on in his body. By the time the diagnosis is usually made, the process itself has already arrived at a more or less advanced stage.

*Etiology.*—The principal, and by far the most frequent cause of chronic colitis is constipation, which again may be subdivided into various kinds, and according to which the colitis may appear in different forms, and in different parts of the colon. There is the ordinary type of atonic constipation, due to some disturbance of that wonderful, but still so little understood automatic nervous mechanism, governed by the sympathetic system. The arteriosclerosis of the abdominal vessels; the abnormalities in the length of the gut in its different subdivisions, and of the mesocolon; abnormal mobility (cecum mobile); general enteroptosis; kinks in the gut; constrictions as the consequence of adhesions after operations, or other abdominal affections; all these and many more factors may lead to stasis of the intestinal contents or constipation. Further and more detailed discussion of this subject is beyond the scope of this article. It may be permitted to mention here that in aiding to unravel the often complicated and obscure conditions, some of which have just been mentioned, the Roentgen rays may be of real value. It cannot, however, be repeated too emphatically that the radiographs, inasmuch as they show only shadows and not real pictures, can never suffice for a reliable diagnosis, unsupported by other evidence, by themselves alone. On the contrary, they may often be directly misleading. Radiography in its proper sphere is merely a part, and often a very important part, of the general physical examination, and the radiographs can be correctly interpreted and furnish reliable data only if taken in conjunction with the results obtained by all the other physical and clinical methods. The further etiology of chronic catarrh of the colon is practically identical with that mentioned for acute catarrh.

*Pathology.*—The pathology is still not as clear as one would like. Here, as in the acute form, the formation of excessive mucus is the principal feature. The very thin, hardly perceptible, almost cell-free mucus, that is found on the exterior of somewhat hard scybalous feces is the earliest sign of an incipient chronic colitis. In more advanced conditions, mucus becomes increasingly plentiful, and epithelial cells are cast off in great abundance. With the further advance of the process the inflammation and its products begin to penetrate below the surface of the mucous membrane. The interstices between the crypts, and even the submucosa are invaded by round-cell infiltration, and this may gradually extend

to the muscular coats and fill the intramuscular spaces. These primary conditions are apt to lead to secondary changes in various directions. The surrounding and choking of the crypts and follicles by the cellular infiltration, can result in small cysts, or again in minute abscesses. These latter, when small and near the surface of the mucosa, usually discharge into the lumen of the gut, and do not cause much disturbance. On the other hand, they may spread not only horizontally, but also downward, into the submucosa, and from there through the muscular layers, down toward the serosa. From here, they may perforate directly into the peritoneum; or, what is more common, cause local peritonitic patches, adhesions, etc. As a result of the chronic inflammation and its destructive effect upon the epithelium and the glandular apparatus, atrophy of the mucous membrane, and at times, even of the muscular portion of the intestinal wall, is observed. Very often the effect of the chronic process is to cause hypertrophy, so that, as a late stage of chronic colitis, cases are not infrequently seen where the mucosa and submucosa are very materially hypertrophied and thickened. In some of these cases, practically the entire colon, from beginning to end, presents one mass of superficial and deep-seated ulcerations covering the hypertrophied and infiltrated deeper layers of the intestine. Similar forms are occasionally observed in which the mucous membrane, though thickened and infiltrated, is not ulcerated, but covered with polypoid excrescences (colitis fungosa). Both forms are often the cause of protracted and profuse hemorrhages, not infrequently directly menacing the life of the patient. The treatment in these cases is generally supposed to be necessarily surgical, but quite recently Th. Rosenheim[2] seems to prove that these cases have a better chance of recovery without operation.

*Symptoms.*—In its very earliest stages, chronic colitis hardly gives rise to any marked subjective symptoms. The bowels are sluggish; as a rule, they are evacuated every three to four days, sometimes with a certain amount of griping pain, usually with copious formation of gas. At a later stage, diarrhea is apt to alternate with constipation. It is probable that the entire colon is involved, whenever the feces are soft and mushy. Thin and watery stools, accompanied by colicky pains, are the usual symptoms of involvement of the entire intestinal tract. Uncomplicated chronic colitis is accompanied by few, if any, systemic symptoms. There is no fever, no loss of weight or strength. In very old cases, one hears complaints of fatigue and general weakness.

It is very seldom that, in chronic colitis, the sigmoid flexure, the descending colon, and the rectum, in some cases the colon in its entire extent, cannot be distinctly felt, as somewhat thickened strands and usually tender to pressure. In this way, also, the stasis of fecal material can always be recognized. This sensitiveness to touch increases with the advance of the inflammatory process, and by these means it is very often possible to localize the lesion and to obtain a fairly accurate idea of how much of the colon is affected, and which of its subdivisions are especially involved. It is necessary, however, to remember that often enough chronic colitis runs its entire course without producing subjective symptoms, and in consequence, no objective symptoms are recognized. The patient may fight all his life, and apparently unscathed, with constipation. On the other hand, suddenly and without warning, septic or peritonitic symptoms of a highly pernicious type can set in, as consequences of colonic ulcers or other lesions, which until then had been entirely latent.

Sigmoiditis and Perisigmoiditis.—Although occasionally mentioned under one name or another (pericolitis) this special form was first fully described in 1893 by Mayor.[3] Since the fundamental work of this author much has been written on the subject, but practically nothing new of any importance has been added.

The sigmoid flexure, as is well known, is the most movable portion of the colon, and is hardly ever of the same length or position in any two individuals. The feces arrive here, more desiccated and therefore less movable, and hence this locality furnishes the best possible opportunity for fecal stasis. The sigmoid, even in perfectly healthy individuals, is rarely found quite empty. It can nearly always be distinctly palpated as more or less thickened, and variable quantities of fecal contents. Under normal conditions, the sigmoid is not tender to pressure. Now it happens, however, that an acute inflammatory process is observed, in which the sigmoid flexure, either in part or in its entirety, can be felt, can not infrequently even be seen from some distance, as a pronounced tumefaction. This is extremely painful to the touch, nearly always accompanied by some rise of temperature, which at times is initiated by a chill, and which not infrequently rises as high as 103° to 104°. There is often marked muscular rigidity, now and then some nausea or vomiting, and feces and flatus are not passed. There are present, in one word, all the signs of a local peritonitis, very much resembling an acute attack of appendicitis, though all the objective symptoms are more superficial. Such attacks of acute sigmoiditis may cause considerable worry to the physician and much alarm to the patient, and unnecessary laparotomies are often resorted to. As a rule, however, these cases overcome their acute and threatening symptoms surprisingly quickly. They may be compared to the local peritonitic involvement so frequently complicating subserous fibroids. Like these, the acute attacks of sigmoiditis cause adhesions. An ice-bag applied to the tender swelling, a good dose of calomel or castor oil, a starvation diet suffice, as a rule, to cause all distressing symptoms to disappear within a few days. This, however, does not mean that the sigmoid has returned to the normal condition. The acute inflammatory state has become converted into a more chronic and, in view of its possible ultimate consequences, a graver inflammation—chronic sigmoiditis. Here again, fecal stasis, with all its toxic and infectious accompaniments is the main etiological factor. In the chronic cases, too, acute exacerbations may occur.

There are not many autopsies available, and hence the minute structural pathology has not been so accurately studied as might be desired. It seems that both acute and chronic sigmoiditis are diseases principally of the submucosa, and Mayor in consequence proposed to name the process "Local Submucous Enteritis." With this is coupled the tendency to spread downward toward the peritoneum, as described above, which very readily leads to peritonitis, and to all those inflammatory and other processes on the outside of, and surrounding the sigmoid, and classified as perisigmoiditis. These acute cases of perisigmoiditis are often followed by the most grave consequences: abscesses, phlegmonous infiltration often extending over the entire left iliac fossa; perforation of the gut or of the abscess leading to general peritonitis. Not infrequently small diverticula complicate the process. After the subsidence of the most acute symptoms, strictures may result, causing obstruction, even leading to ileus. In chronic cases, there is usually a relaxation of the gut, in consequence of which the toxic fecal material, not being promptly discharged, is more amply absorbed, and thus results a combination of mechanical with chemical lesion. Not infrequently, however, there is, instead of relaxation, a marked tendency to *spasm*, without there being any change in the ultimate results of the process. In the absence of those most severe results just mentioned, there may still be present, for a long time, a more or less firm, uneven mass, painful to

touch, which, coupled with constipation, griping or burning pain, spasm, and occasionally bloody stools, may be very strongly suggestive of some malignant growth (carcinoma). Examination of the feces usually fails to give reliable differential data in these cases; but by the expert use of the proctoscope or romanoscope it is possible, in the great majority of cases, to differentiate with all desirable accuracy between chronic sigmoiditis or perisigmoiditis, and cancer of the colon. Probatory laparotomy for diagnostic purposes will rarely be found necessary. Surgical interference will, however, be indicated in cases of perisigmoidal abscess, phlegmons, etc., and for the release of constricting or otherwise troublesome adhesions. In those cases in which operative interference is not indicated, the principal therapeutic measures will again be proper diet, mild laxatives, irrigations, etc., according to the peculiarities of each individual case.

It is still a matter of discussion whether a chronic colitis or sigmoiditis, when once established, can ever again be cured. According to the present state of our knowledge, it seems highly improbable that a complete restitutio ad integrum can be obtained after these chronic inflammatory conditions have once taken a thorough hold of the intestine. It is, however, quite certain that while a great many, perhaps the majority of the cases of chronic colitis, will retain some symptoms, even if not of great significance, for the remainder of their lives, there are others, and occasionally extremely severe ones (Rosenheim[4]) that have been cured, at least to this extent, that no further subjective or objective symptoms have become apparent.

Enteritis Membranacea.—One more form of chronic colitis deserves mention. It has been described under various names, and very frequently confounded with mucous colitis. The name enteritis membranacea, following the example of Nothnagel, is perhaps most appropriate. It very frequently complicates the so-called mucous colitis, but must not be confused therewith. It is a chronic catarrhal condition most frequently of the lower portions of the colon, in which a very abundant desquamation of the epithelial cells takes place, the cells predominating very largely over the mucus, and therefore discharged in the form of membranes or tubular casts of the intestine, and are more dry and less succulent than ordinary colonic mucus. The whole process is nothing more than a desquamative catarrh of the lower portions of the colon, the symptoms being the same as those of any other mild chronic colitis. When combined with mucous colic, the symptoms of the latter predominate.

Mucous Colitis.—The peculiar group of symptoms variously termed mucous or membranous colitis or enteritis, colica mucosa, pseudomembranous enteritis, fibrinous enteritis, etc., constitutes an affection preëminently of the female sex. According to Litten, eighty per cent., according to Kitagawa, as much as ninety per cent. of all observed cases occur in women. It is found, however, not infrequently in men and even in children. Löwenstein reports the case of a boy three years old.

The women suffering from mucous colitis show, as a rule, well-marked, more or less extensive neurotic or hysterical stigmata. The same holds good for children. The men also are usually distinctly neurotic or hysterical.

Of late years the clinical symptoms and the pathology of this disease have been the subject of much discussion, though nothing essentially new has been brought out since the masterly essay of the late Dr. Da Costa.[5]

*Symptoms.*—The more important clinical symptoms of mucous colitis may be briefly summarized as follows: Pathognomonic for the affection are the peculiar evacuations from the intestines. Preceded by more or less pain of a colicky character and of varying duration, masses of a grayish white, somewhat translucent, substance are evacuated. These masses vary in quantity and in form; at times they appear as shreds, single or netted together; sometimes as balls and lumps; again as membranes or as longer or shorter apparently solid ropes, or again in tubular configuration representing complete casts of segments of the gut. In some cases only a comparatively small quantity is passed; frequently, however, the mucous masses are very abundant and sometimes appear in really enormous quantities. Feces are as a rule rarely passed with these masses, which form practically the sole constituent of the stools. When floated and disentangled in water it becomes apparent that in every instance these masses are rather membranous, and are rolled up or balled together to resemble lumps, tubes, ropes, etc. Chemically this substance presents all the characteristic reactions of mucin; though sometimes and inaccurately called fibrinous, no fibrin has as yet been found whenever careful chemical examination was made.

Microscopical examination shows, besides mere traces of fecal matter, the characteristic striated thready mucoid substances intermingled with innumerable epithelial cells either discrete or else in connected layers. It is of importance to note that leucocytes are never found in great numbers, but occur rather singly here and there, thus offering no suggestion of inflammation or suppuration.

With the discharge of these mucous masses the colic is usually relieved. In rare cases one single attack ends the affection. As a rule the seizures occur again and again. There may be intervals of weeks or months between the attacks, during all of which time the patient may feel entirely well. The attack itself may last for days or weeks or even months. A single attack of colic may occur each day, or there may be several if not numerous ones, so that the patients are often convinced that they have diarrhea or dysentery.

The pain is variously described as griping, burning, cutting, pressure, etc. Not infrequently there is considerable tenesmus. The pain is located in some portion of the colon, most frequently in the sigmoid flexure or in the cecum. If in the latter place, it frequently gives rise to a suspicion of appendicitis in the mind of the patient as well as of the physician. From these points of origin the pain radiates toward various parts of the abdomen, most often toward the umbilicus and epigastrium; quite frequently also down one or the other thigh, especially down the left. The abdomen may be more or less distended, but is mostly quite normal and soft. Fever is never present in uncomplicated cases. Nausea is often complained of during the attacks, but vomiting is rare.

Enteroptosis is often associated with this disease, and gastric hyperacidity is not an infrequent concomitant. Characteristic of uncomplicated cases is the fact that in the intervals between the attacks there are no intestinal disturbances, and the patient, aside from possible neurotic complaints, seems quite normal. A great number of this class of patients attribute their pains and discomforts to gastric and intestinal indigestion. They endeavor to establish a connection between the attacks of colic and indiscretions in diet. As a consequence they soon come to dread almost every sort of nutritious food, and, living on an entirely insufficient and irrational diet, lose rapidly in weight and strength, without their local condition being at all benefited. On the contrary, it can be easily seen that in all these cases, with the loss of flesh owing to insufficient nutrition and the accompanying increase of neurotic conditions, the malady becomes steadily worse.

*Pathology.*—As regards the pathology of this disease, there are still some differences of opinion. Some

few still maintain that mucous colitis is an organic lesion of the colon, a true inflammation, a catarrhal or even an ulcerative process, and that besides an abnormally abundant secretion of mucus, portions of the mucous lining are detached and voided in the form of shreds and membranes. There are, however, serious, and it seems to me, conclusive objections to this view. It is true that dead-house material, by means of which one may study this class of cases, is very scanty indeed. Those cases, however, which while well observed during life were carefully examined after death by competent observers (Rothmann), showed no anatomical lesions whatsoever. The gut was entirely normal. These observations tally well with the results of the microscopical examination of the mucous discharges. The absence of all evidence of pus, the scanty occurrence of leucocytes, the absence of blood or of any constituents of the intestinal lining with the exception of epithelial cells, all point in the same direction. The multitude of epithelial cells that can be seen in every mucous discharge, and the fact that they are often present in extensive layers, do not of themselves speak for any anatomical lesion. It is well known that intestinal epithelium comes away very readily and yields to slight mechanical influences, and every normal stool contains great numbers of epithelial cells.

The facts that the majority of these cases occur in women, and that in nearly every instance neurotic or hysterical stigmata of various kinds can be established, speak also most emphatically for the merely functional character of this disease. It is therefore safe to assume that the so-called mucous colitis is no colitis at all, but, as was long ago suggested by Da Costa, and more recently clearly stated by Leube, a secretory neurosis, often combined with a neurosis of motility, characterized by the abnormal and excessive secretion of mucous in the colon, and on a par with well-known secretory neuroses in other organs. It would be well, therefore, if the name colitis mucosa were abandoned altogether and, following the suggestion of Nothnagel, the disease termed mucous or membranous colic.

It must be borne in mind, however, that this neurosis, like any other, may complicate other organic lesions. Thus, besides the mucous colic, genuine intestinal catarrh may be present. And it is the duty of the physician in every instance to determine first of all whether he has to deal with a case of mucous colic, that is, a pure functional neurosis, or whether there are anatomical lesions—catarrh, ulceration, neoplasm, etc.—complicating the neurosis.

*Treatment.*—In considering the therapeutics of mucous colic it appears difficult or rather impossible to outline any special method of treatment. As in every other form of neurosis, each individual case must be studied and treated by itself. It is above all necessary to obtain the patients' confidence, to inspire them with the conviction that they can and will get well, and thus become assured of their implicit obedience in the carrying out of every order.

The habit which this class of neurotics invariably cultivate of anxiously scrutinizing each stool for mucus must be stopped. An inestimable advantage is gained if the patient no longer knows that mucus is discharged. Strict attention must be paid to diet. In all uncomplicated cases the diet should be as little restricted as possible and selected with a view to counteracting the habitual tendency to constipation, and increasing the weight and strength. Nothing encourages patients so much as when they find themselves enjoying their food and gaining weight. Exercise in the open air and rational hydrotherapeutics are valuable aids in the treatment of this form of neurosis as in all others. General massage may also be employed, but abdominal massage should be rigorously avoided. Local treatment of the gut by means of injections has been widely recommended. The astringent injections, especially of nitrate of silver, copious lavage of the bowel by means of high enemata or injections, etc., are still favorite methods of treatment in this malady. It is our conviction that all these methods are more harmful than curative. It is not wise in these cases to resort to any remedial measures which keep the patient's attention, already too much occupied with his ailment, still more centered upon his intestinal condition. Aside from this psychological objection, the fact is well established that astringent injections, be they never so mild, even enemata of plain water or of saline, have a direct tendency toward increasing the secretion of mucus. It is indeed possible by means of nitrate of silver to produce artificial casts of the gut. All local treatment, therefore, injections of all kinds, suppositories, etc., etc., should be strictly avoided.

When dietary measures alone are not sufficient to relieve constipation, mild aperients, such as cascara, castor oil, an occasional dose of calomel, etc., may be given. The salines in uncomplicated cases in which no intestinal catarrh is present do not, as a rule, act well. The attacks of pain and the tenesmus, when present, may be relieved by small doses of codeine or opium, though it must be borne in mind that this class of drugs should be employed most grudgingly. Besides the usual roborant and tonic medication (iron, strychnine, etc.) when indicated, good effect is frequently seen from nitrate of silver given by mouth in the form of enteric, keratin-coated, or salol-coated pills in doses of gr. $\frac{1}{6}$ to $\frac{1}{4}$ three times a day. Sulphate of atropine in doses of gr. $\frac{1}{240}$ three times a day may also be of use.

Altogether the treatment must be mostly moral and hygienic, and, while all local interference with the intestines should absolutely be avoided, the use of drugs should be restricted as much as possible.

In conclusion it is well to state again that this method of treatment applies only to the uncomplicated cases of pure mucous colic. In all those cases in which there is organic lesion—be it catarrh, ulceration, or neoplasm—and in which the mucous discharge and the neurotic condition are merely complicating incidents, it is obvious that the whole force of treatment must be directed against the organic process.

ISAAC ADLER.
O. F. KREHBIEL.

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**Collagen** forms the basis of white fibrous connective tissue and the organic basis of bone. It is chiefly characterized by its great insolubility and belongs to the group of proteins classed as albuminoids. Collagen is not a true protein since it is unable to supply the nitrogenous needs of the body. By boiling with water it is readily transformed to gelatin, which is also an albuminoid. Collagen is dissolved by gastric juice and also by pancreatic juice, if it has been previously subjected to the influence of acid or has been heated with boiling water.

FRANK P. UNDERHILL.

**Colliculus Inferior.**—Also known as the posterior quadrigeminal body. Bechterew (1885) was among the earlier investigators of the inferior colliculus to show its relations to the cochlear portions of the acoustic nerve and hence its importance in hearing. For the most part the results obtained by him in Flechsig's laboratory have been verified and amplified chiefly by the work of Baginsky, Kirilzer, Held, Van Gehuchten, Lewandowsky, Winkler, Spitzer, and Karplus. The inferior colliculus, in part with the median geniculate body, form the two chief secondary synapses of the auditory pathway. The neurones of this pathway are as follows:

First Neurone: Sensory receptor in Corti's organ, ganglion spirale; (*a*) ventral cochlear nucleus and (*b*) acoustic tubercle.

Second Neurone: (*a*) Ventral cochlearis nucleus—corpus trapezoides—superior olives—ventral and dorsal lemniscus nuclei of opposite side; (*b*) acoustic tubercle and striæ acusticæ, superior olive of both sides.

Third Neurone: Superior olive, lemniscus nuclei (lateral lemniscus), colliculus inferior (post. quadrigemina).

Fourth Neurone: Inferior colliculus, arm of colliculus, median geniculate body.

Fifth Neurone: Median geniculate—temporal auditory cortical area.

Cajal assumes that the cells of the inferior colliculus are not direct but collateral synapses for shunting auditory stimuli (reflexes) to other mechanisms, ear movements, head movements, voice production, eye movements in part. The complete anatomy of the hearing pathways is discussed in the article in *Brain, Anatomy of.* Anatomy teaches that the pathways for sound are crossed and uncrossed, as are other sensory pathways, hence a lesion of one colliculus causes no marked deafness although interfering somewhat with hearing and more especially many hearing reflexes. Experimental stimulation of the inferior colliculus has brought about dilatation of the pupil of the opposite side—raising of eyebrows, protrusion of eyeballs (autonomic stimulation with fear reactions from sound stimuli in normal physiology), turning of the head up toward the non-stimulated side, movement of ears (in animals), and a number of laryngeal and respiratory stimuli causing voice production (cries, grunts, etc.). Ferrier, who performed a number of such experiments, came to believe that a psychical center was revealed. Prus obtained somewhat similar results, which, with the information available from the studies in the sympathetic nervous system, would tend to show that the auditory synapses in the inferior colliculus constitute a large factor in psychical reactions to sound stimuli as expressed through the autonomic vagus distribution. Cocainization of these bodies caused clonic convulsions, raising of the head, movements of the eyes to the opposite side, dilatation of the pupils, exophthalmus, cardiac cramp, and loud crying, *i.e.* typical epileptiform phenomena. Prus interpreted the results as showing a motor center, but seen from the standpoint of vegetative neurology it would appear that disharmonic vagus activities come into activity (Lewandowsky) through cutting off of psychical (thalamic homologue) control, *i.e.* thalamic over-response occurred in the sense in which Head has described it for the thalamic lesions in which tactile sensibility was under discussion. These reflections would lead one to review the subject of the psychical origins of certain epileptic attacks associated with infantile fear shock obtained through auditory impressions, in which connection Oppenheim's remarks concerning over-response to sounds as seen in diplegias[1] might have wider significance than he seems to give to them.[2] Furthermore the problem of tone production, as contrasted with tone perception, acquires wider significance than given to it by the original Helmholtz peripheral hypothesis, since the reflex activities of the tensor tympani are apparently involved in colliculus inferior disorder. Bechterew has further shown that the sexual apparatus (erection, contraction of uterus, stimulation of milk secretion) is also reflexly affected through the inferior colliculus. As the autonomic pelvic functions are homologues of the vagus autonomics this seems logical, and contributes further light to the Freudian hypothesis of the relation of suppressed sexuality (incest, homosexual complexes) to certain epileptic attacks (Maeder). From the reflex, somatic side, a study by Frey and Fuchs[3] is of interest on the subject of reflex epilepsy and ear and nose disease, also the classical reports of Hughlings Jackson[4] and Ormerod.[5]

Clinical neurology still lags behind the anatomical and physiological correlations. Charcot has noted a tabetic with deafness in whom the inferior colliculus was involved. Flechsig has recorded hallucinations of hearing and Weinland has called attention to disturbances of hearing from lesions of the inferior colliculus, which hypothetically to be constant mean double lesions, and possibly incorporating other (*i.e.* geniculate) fibers. The relationships of disturbed autonomic functions to collicular disease have not received sufficient attention from neurologists nor fromotologists. The literature on deafness with dumbness has not been gone into but will repay consultation. The tinnitus of neurasthenia, of the psychoneuroses, the great importance ascribed to sounds in many psychoses, hallucinations in schizophrenics in manic-depressives, have as yet received no satisfactory analyses from either the neurological or the psychiatric disciplines.

See Oppenheim, Lehrbuch der Nervenkrankheiten, 6th edition, p. 1317; Starr, Central Deafness, *Journal of Nervous and Mental Disease*, July, 1910; Lewandowky, Handbuch der Neurologie, Vol. I., p. 919, for most valuable article by Bárány, and literature.

SMITH ELY JELLIFFE.

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**Colliculus Superior.**—This is also known as the anterior quadrigeminal body. The general topographical anatomy has been discussed in the article on *Brain, Anatomy of*, in vol. ii. The finer anatomy of the superior colliculus shows it to be a highly complicated structure. It is arbitrarily separated from the lower structures of the midbrain. (See *Brain, Midbrain Diseases.*)

A section at about the center of the midbrain shows the following structures: (1) An outer white layer, the *stratum zonale*, made up chiefly of fibers derived from the optic tract. There are also fibers from the superior quadrigeminal brachia and small horizontally lying nerve cells. (2) A gray layer, *stratum cinereum*, made up chiefly of ganglion cells whose axis cylinders proceed inward. These are cells making up the synaptic junctures of the optic tract fibers and are concerned with establishing collateral associations with other nerve pathways, chiefly the oculomotor pathways to the nuclei of the eye movements and also to those of the neck and body. (3) A layer of white fibers, containing the greater mass of the optic tract fibers which are terminating about the ganglion cells of the third and the fourth layers. (4) A middle gray layer of cells or collateral associations. (5) The lemniscus layer made up probably from fiber of the median and lateral lemniscus. (6 and 7) Layers of ganglion cells with axones passing to the opposite side or passing ventrally to the aqueduct and central gray which decussate and

form the tectobulbopontospinal tract going to the anterior columns (head, neck, and trunk associations). Fibers from the spinothalamic tracts and from the occipital and temporal cortex are also present.

This whole structure is part of the pathway for the mechanism of sight. It is in connection with:

(*a*) Centripetal pathways:
1. From the optic tract through the anterior brachium of the superior colliculus.
2. From the spinal cord through the posterior columns, their nuclei, and median lemniscus.
3. With the spinal cord, lateral columns, tractus spinotectalis.
4. Occipital lobes through the internal sagittal layers.

(*b*) Centrifugal pathways:
1. To the occipital optic cortex by means of the anterior brachium.
2. To the medulla and spinal cord by means of the tectobulbopontospinal tracts.
3. To the nuclei of the oculomotor muscles (light reflexes, etc.).

Thus the reflex collaterals in the superior colliculus are homologous with those in the inferior colliculus, the former subserving to join up light stimuli with the rest of the body—with sympathetic, sensorimotor, and psychical levels, the latter subserving homologous functions for sound stimuli. These reflex collaterals do not subserve any optical functions properly speaking.

From these anatomical considerations it follows that a complicated symptomatology may result from colliculus lesions which will vary according to which tracts or groups of cells are involved. Minute lesions, as in poliomyelitis, encephalitis, cysticercus, small tubercles, miliary aneurysms, may cause very few syndromes, isolated reflex disturbances, whereas gross lesions from pressure of tumors—pineal, tubercle, sarcoma, etc.—may cause more widespread symptoms. One of the more roughly grouped of these is the so-called Nothnagel syndrome. (See *Brain, Midbrain Diseases*, vol. ii.)

Lesions limited to the structures of the superior colliculus do not cause blindness, nor hemianopsia. The lesion must extend as far as the geniculate bodies to reach those optic tract fibers which are continued further back to the occipital cortex as sight fibers. Although fibers may go from the colliculus to the occipital lobes, just what relationship they have to seeing is still uncertain. The chief disturbances of pure colliculus superior disease are in the pupillary reflexes, eye movements, and balancing functions through eye movement.

The pathways taken by the pupillary fibers are not cleared up completely as yet. They pass with the tractus in its middle portion, pass through the brachium anterius colliculi, also in the surface of the pulvinar, and end in part in the superficial gray layer of the superior colliculus. Here a synaptic junction takes place to connect up with the oculomotor. Lesions limited to these pathways may cause inequality of the pupils, possibly the Argyll-Robertson phenomenon. Such may follow trauma, alcoholism, or syphilitic meningeal exudative or infiltrative processes. The overwhelming majority of such lesions are syphilitic.

A group of peculiar associated eye palsies are found

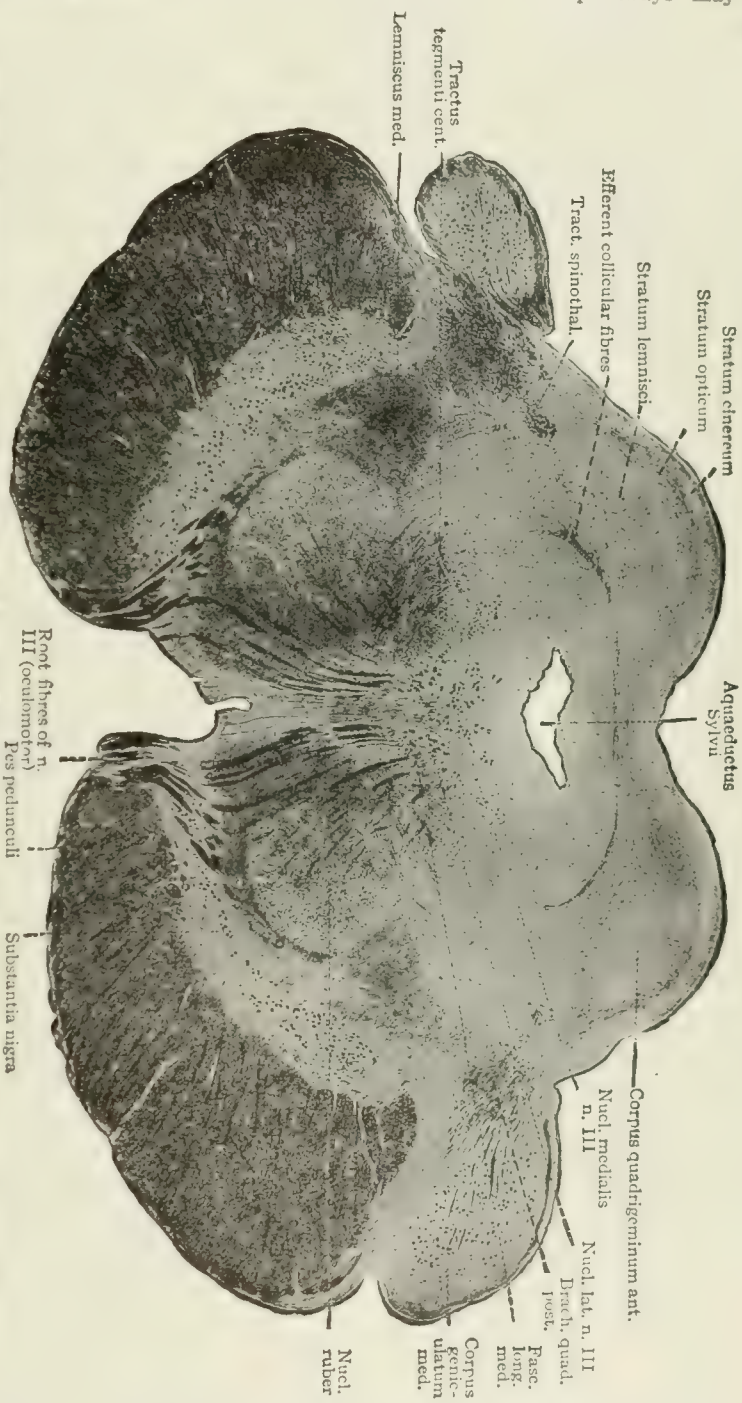


FIG. 1480.—Transverse Section through Midbrain at Level of Superior Colliculus and Exit of Nerve III. Weigert preparation. (Rauber-Kopsch.)

in lesions affecting either the colliculus itself or its connections with the eye-muscle nuclei. Thus a break in the connections between the abducens and the colliculus will result in a palsy of the rectus internus on looking to one or the other side or of only one side without any palsy of the abducens. Internus associated palsy without loss of convergence may occur (Fischer, Bielschowsky). The precise anatomical details are as yet lacking. Vertical conjugate palsy has been frequently described mostly as due to tumors pressing upon the colliculus or involving it. Here the eyes may be directed to right or left but cannot be raised or lowered, or only one of these capacities is lost. In looking down, the eyelids do

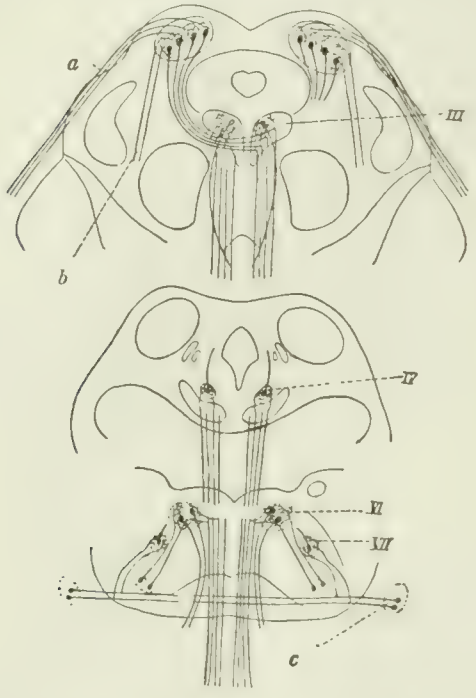


FIG. 1481.—Diagram Showing the Origin and the Course of the Fibers of the Reflex Tract Uniting the Terminal Ramification of the Optic Fibers with the Nuclei of Origin of the Oculomotor Nerves. (Van Gehuchten.) *a*, Optic nerve fibers; *b*, sensory fibers of the median lemniscus; *c*, accessory nucleus of the acoustic nerve.

not sink. Most of the described lesions are so gross that it is difficult to localize the precise mechanisms. Lewandowsky regards these palsies as due to a break in the pathways going from the cortex to the oculomotor nuclei.

The chief producing lesions are tumors (gumma, teratoma, sarcoma, abscess, cysticercus, etc.), multiple sclerosis, encephalitis, arteriosclerosis, etc.

More extensive eye-muscle palsies are referable to colliculus disease, especially if the lesion press further caudad toward the nuclei themselves, or involve the posterior longitudinal bundle.

Ataxias are similarly present in disorder here from implication of the eye-muscle functions of horizontal vision but they are not a picture of pure colliculus disease, neither are the complex motor disturbances of choreic, paralysis agitans, or athetoid character such as have been described in von Monakow and other classics. These are due more particularly to cerebellar and vestibular pathway disturbances. (See *Cerebellum, Disorders of the*, and *Adiadochokinesia*.)

That the superior colliculus is associated with other motor reflexes is certain, but no precise localizing symptomatology is known. The reflex collaterals with the sympathetic permit the fear reactions through sight—and all of the considerations concerning the relations of the psyche to hearing mentioned in the paragraph on the inferior colliculus are pertinent to the superior colliculus, and even more important. See *Brain, Midbrain Diseases*, and *Cerebellum, Disorders of*, for study of syndromes due to disease of adjacent structures.

SMITH ELY JELLIFFE.

**Colliculus Urethralis.**—The recent improvements in the methods of examining the posterior urethra, have made it necessary for us to change our entire conception of the pathology and therapeutics of that portion of the male urinary tract.

Hitherto it has been generally believed that chronic gonorrheal urethritis was caused solely by a persistent inflammation involving the prostatic gland and its adnexa; in the latter term were included the seminal vesicles principally as well as the adjacent tissues. The perfected urethroscope, however, has demonstrated that while the prostate and vesicles are the seat of inflammation in the vast majority of cases of chronic gonorrhea, there is a large proportion of cases in which no appreciable lesion can be demonstrated in the prostate or seminal vesicles, whereas the only evidence of disease may be found in the colliculus, or verumontanum.

Until this little organ became demonstrable with the posterior urethroscopes of modern type, very little was known about it. Text-books said it was a little ridge extending along the prostatic urethra and that its function was associated in some way with the sexual system. However with the aid of artificial illumination and the magnification which the most recent instrument gives us, it is quite possible to determine lesions and pathological conditions that were entirely unthought of hitherto.

The appearance of this little organ is of more than passing interest. As a matter of fact its appearance on examination depends in a great measure on the type of examining instrument used. Examined first with a simple straight or curved tube and then with one of the later types of instrument, the difference is seen to be very striking. With the simple tube the colliculus is seen (though sometimes it cannot be seen at all) as a small swelling, rather poorly illuminated and protruding into the posterior urethra like a small red pea (Plate XXVIII, Fig. 1). A positive diagnosis based on such a picture is next to impossible. With the newer instruments, however, the colliculus is seen as a distinct, well-lighted projection from the floor of the urethra into the urinary canal. Generally it may be said to resemble an enlarged glans clitoridis, or in some cases it resembles a small cherry or strawberry. Sometimes it assumes a domelike shape, with the opening of the utricle situated at the pointed or flattened summit (Fig. 2); often it resembles a cone, the walls rising and meeting sharply in a pointed peak (Fig. 3); occasionally the peak is flattened as if the apex were sawed off (Fig. 4); again it may assume a rounded bulbous shape, resembling a spherical doorknob or an electric bulb (Fig. 5). Whatever its shape may be in the normal condition, the general outline remains pretty much the same in disease, except that the smooth walls may become turgid and roughened or replaced by corrugations, excrescences, or cysts of distinctly inflammatory origin (Figs. 6 and 7).

As a rule the utricle is placed at the summit of the colliculus, flanked on either side by the ejaculatory ducts. There are exceptions to this rule. The utricle may be seen on the anterior or on the posterior wall, and the ejaculatory ducts may be observed near the summit or adjacent to the base. Not infrequently tortuous blood-vessels may be seen crossing the anterior wall from side to side or mounting the anterior aspect, only to disappear in the mucous membrane of the urethral wall. Generally the walls slope gradually and gracefully downward and

EXPLANATION OF
PLATE XXVIII

## EXPLANATION OF PLATE XXVIII.

FIG. 1.—Colliculus seen through a Simple Straight or Curved Tube. (Natural size.)

FIG. 2.—Dome-shaped Colliculus, with utricle situated at the apex. (Slightly enlarged.)

FIG. 3.—Cone-shaped Colliculus, with utricle situated on the anterior aspect near the apex. (Slightly enlarged.)

FIG. 4.—Colliculus with Flat Top, utricle situated on anterior aspect. Note ejaculatory ducts in lateral sulci. (Slightly enlarged.)

FIG. 5.—Doorknob or Bulb-shaped Colliculus. Compare with Fig. 2. Note the slight magnification and greater illumination obtained with the cystourethroscope. (Natural size.)

FIG. 6.—Colliculus almost Covered with Small Cysts. Utricle situated at the apex. (Slightly enlarged.)

FIG. 7.—Unusually Large Cyst Projecting from the Anterior Wall of the Colliculus. Small cyst is seen on the posterior wall. (Natural size.)

FIG. 8.—Multiple Cysts on the Roof of the Urethra near the Colliculus.

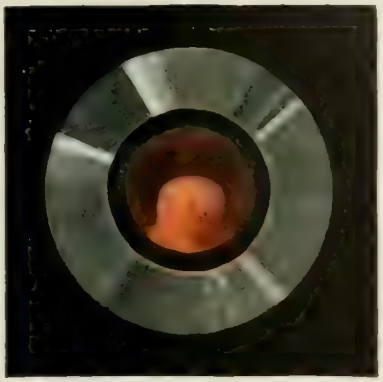

Fig. 1.

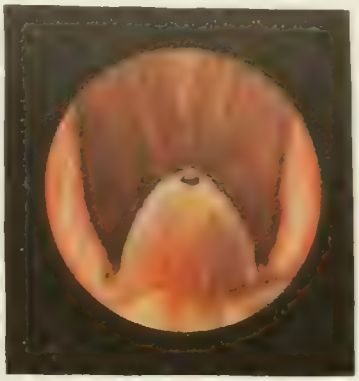

Fig. 2.

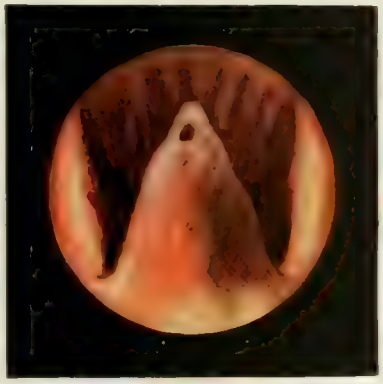

Fig. 3.

Fig. 4.

Fig. 5.

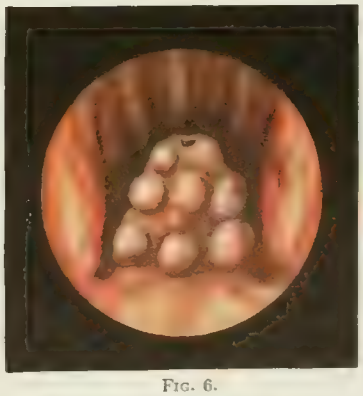

Fig. 6.

Fig. 7.

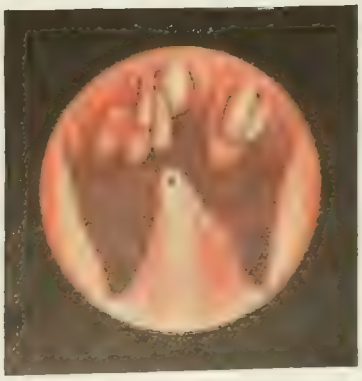

Fig. 8.

ENDOSCOPIC VIEWS OF THE COLLICULUS.

laterally, forming a concave trough-like lateral sulcus, beyond which rises in an unbroken and continuous curve the lateral wall of the urethra (Fig. 5). On the other hand, the lateral sulcus may appear in the shape of a deep, narrow trench, created by the sharp junction of the apposing walls of the colliculus and the urethra. In these cases, we find the prostatic ducts, from three to six or more in number, long and narrow, with the appearance of deep slits (Fig. 4). When these apparent slits are probed carefully it will be found that they look deeper than they really are; this is due, in all probability, to variations in the illumination and the development of shadows.

Colliculitis (Verumontanitis).—We are not yet sufficiently acquainted with the colliculus and its pathology to state in detail all the ills to which it is subject. We may safely say, however, that the most common pathological condition of this organ with which we have to deal is the inflammatory process following or coincident with a gonococcus infection of the deep urethra and prostate.

It is evident that the colliculus must suffer involvement in practically every case of posterior gonococcal urethritis; this is particularly important to remember in connection with the frequency of involvement of the ejaculatory ducts and prostatic sinuses. Hence we must not be surprised to find inflammatory conditions of the colliculus in cases of premature ejaculation, sexual impotence, sterility, and the male neuroses. In these cases we often find the colliculus deeply congested and swollen, its margins ragged and showing evidence of cystic changes. Occasionally we find a number of cysts on the roof of the prostatic urethra, adjacent to the colliculus (Fig. 8) and giving rise to urinary or sexual symptoms. It is well to remember that inflammation of the colliculus is not always of gonococcus origin necessarily, any more than such is the case with chronic prostatitis; any continuous and persistent irritation involving the sexual function may be responsible for the development of the inflammatory process. Among these the principal causes are bad sexual habits, coitus interruptus or withdrawal, frequent and excessive masturbation, and persistent excitement without gratification. Fortunately, colliculitis due to any of these causes responds quite readily to local treatment applied through the urethroscope.

Defecation spermatorrhea, a very common complaint, is usually ascribed to the existence of a chronic inflammation of the prostate. In a case which I had the opportunity to study, I found no evidence of prostatitis, but the colliculus was enlarged, turgid, and congested; the spermatorrhea made a rapid disappearance after a course of treatment of the colliculus without any treatment of the prostate.

Treatment of the colliculus consists almost entirely in the application of silver nitrate and tincture of iodine to the organ through the posterior urethroscope. I prefer a ten per cent. solution of silver nitrate, applied with a cotton carrier; a twenty per cent. solution is often recommended, and I have known instances in which the pure silver stick and the pure tincture of iodine have been used. I believe there is no advantage to be obtained in the use of solutions of such great strengths, and that the reaction is sometimes too great to be of any service to the patient. Bleeding, urinary strangury, and tenesmus, and even complete retention of urine have followed these strong applications of silver and iodine. The galvanocautery may be used with benefit, and the Oudin high-frequency current likewise. The latter is particularly indicated in the presence of cystic and papillomatous growths, and also for the "fulguration" of dilated ducts and glands. Applications should be made at rather infrequent intervals, as we must allow for the passing off of the reaction which always follows. An interval of from four to seven days appears to me the most satisfactory and beneficial.

In conclusion it must be evident that this organ may be the seat of an undiscovered inflammation for a long period of time. It is, therefore, imperative to suspect the presence of disease of the colliculus in every case of deep urethral disturbance, particularly when it has been preceded by a gonococcus inflammation or a history of excessive sexual abuse.

Abr. L. Wolbarst.

**Collodion.**—Collodium (U.S.P.) is a solution of soluble gun-cotton, pyroxylin (*q.v.*), in a mixture of alcohol and ether in the proportions given in the table below. The solution is a syrupy liquid forming an adhesive varnish which, when applied to the skin by means of a soft brush, dries to a waterproof film. It is applied as a protection to diseased or injured surfaces, or can be used as a vehicle for certain medicaments applied externally.

The film produced by the official collodion as it dries contracts with considerable force, and is sometimes useful where local compression is desirable; but for most purposes this quality is an objection, and it is partially overcome in another official preparation, flexible collodion, collodium flexile (U.S.P.). The other official preparations are styptic collodion, collodium stypticum, and cantharidal or blistering collodion, collodium cantharidatum. The formulæ of these and of four other preparations of the National Formulary are given in the following table:

Collodia of the U. S. Pharmacopœia and National Formulary.

| | | |
|---|---|---|
| Collodium (Collodion) . . | U.S.P. | Pyroxylin 4, ether 75, alcohol 25. |
| Collodium Cantharidatum (Cantharidal collodion). | U.S.P. | Cantharides 60, flexible collodion 85, chloroform q.s. |
| Collodium Flexile (Flexible collodion). | U.S.P. | Collodion 92, Canada turpentine 5, castor oil 3. |
| Collodium Iodatum (Iodized collodion). | N.F. | Iodine 5, flexible collodion 95. |
| Collodium Iodoformatum (Iodoform collodion). | N.F. | Iodoform 5, flexible collodion 95. |
| Collodium Salicylatum Compositum (Compound salicylated collodion; corn collodion). | N.F. | Salicylic acid 11, Indian hemp 2, alcohol 10, flexible collodion q.s. ad 100. |
| Collodium Stypticum (Styptic collodion). | U.S.P. | Tannic acid 20, alcohol 5, ether 25, collodion q.s. ad 100. |
| Collodium Tiglii (Croton oil collodion). | N.F. | Croton oil 10, flexible collodion 90. |

R. J. E. Scott.

**Colloid.**—This term is applied to many substances of different origin and nature, but which closely resemble each other physically, in that they are hyaline, colorless, or slightly colored bodies of a gelatinous consistence. The colloid of the thyroid may be taken as the type to which the various bodies designated as colloid more or less conform. There is a great divergence of opinion among writers as to the use of the term colloid, some applying it not only to epithelial products but also to the hyaline changes occurring in connective tissue, to hyaline fibrin, blood-plate fibrin, keratin, keratohyalin, etc.; but it seems best to restrict the use of the word to those hyaline bodies that are formed by the activity of epithelial cells but do not give the staining reactions of mucin or pseudomucin. Even with this restriction in its use it is evident that the term is a collective one and that the substances included under it must differ widely in chemical nature. It seems advisable to the

author to divide the substances known as colloid into two classes: true colloid, as found in the thyroid; and colloid-like bodies, the latter class including all the hyaline products of epithelial cell activity with the exception of mucin and pseudo-mucin (not precipitated by alcohol or acetic acid, but remaining homogeneous when treated by these reagents). The corpora amylacea of the prostate, nervous system, and lung may also be included in this class. The term colloid as applied to "colloid cancer" is a misnomer, inasmuch as this form of cancer is a *mucoid* carcinoma, and does not contain colloid. In this case the term was used because of the gross appearances of the neoplasm (jelly-like or colloid), but does not indicate its chemical nature.

In accordance with this classification, the terms colloid and colloid-like have reference only to general microscopical appearances and not to the ultimate chemical nature of the substance. They all, like mucin, are the products of epithelial-cell secretion, and may represent either normal or pathological forms of secretion.

*True Colloid.*—This occurs normally in the thyroid, where it appears in the form of hyaline, jelly-like masses of the color of honey, filling up the gland spaces and at times extending into the lymph vessels. It is a mixture of different components, the chief of which is an albuminous fluid in which the colloid granules are dissolved to form a homogeneous material. The colloid granules appear first in the cells as acidophile protoplasmic granules which are secreted into the follicular spaces and dissolved in the fluid. Any collection of the substance beyond a certain degree is to be looked upon as a pathological degeneration of the glandular epithelium (colloid degeneration); and from this degeneration the condition known as colloid goiter results. Microscopically, the colloid of the thyroid is hyaline or slightly granular; it frequently contains blood cells, blood pigment, and desquamated epithelium showing varying stages of colloid change. Masses of calcification not infrequently occur in it. The substance is very resistant and is not affected by alcohol or acetic acid. With Van Gieson's stain it is stained yellow or brownish yellow; with eosin and hematoxylin it stains slightly with both the nuclear and the diffuse stain. The consistence of the thyroid colloid varies greatly; at times it is very firm, more often gelatinous, while occasionally it is fluid and soluble in water. It contains the active substance of the thyroid, iodothyrin, which is most probably an albuminous body. It is very probable that the chemical nature of the thyroid colloid is not always the same. Pathological thyroid colloid occurs in colloid goiter (struma colloides cystica) and also in metastases of malignant thyroid tumors.

*Colloid-like Substances.*—These in general resemble the colloid of the thyroid, and are found in the hypophysis cerebri, parotid, renal tubules, prostate, ovarian and parovarian cysts, mammary gland, pancreas, etc. The colloid of the hypophysis is very similar to that of the thyroid both morphologically and chemically, and also contains iodine. The corpora amylacea of the nervous system and lung are also to be included here. In all cases the colloid-like substance appears in the form of a smooth, homogeneous mass filling up the gland lumen or duct, or it may appear in the form of hyaline or laminated concretions. The colloid-like bodies of the kidney tubules are known as *casts*, and are of great clinical importance from their occurrence in the urine in pathological conditions of the kidneys (various forms of nephritis).

Though all of these bodies bear such a close general resemblance to each other, exhibiting similar reactions with ordinary stains, they cannot be identical in their chemical nature either with the true colloid of the thyroid or with each other. Some of them give a characteristic reaction with iodine, others do not, but this varies so much that it cannot be used as a means of classification. We are therefore compelled at the present to apply the term colloid to substances derived from gland cells, which are hyaline, possess a certain degree of firmness, and do not give the reaction for mucin or pseudo-mucin. Beyond this uncertain classification our terminology does not take us. (See also *Hyalin.*)

ALDRED SCOTT WARTHIN.

**Colloid Degeneration of the Skin.**—This is a very rare affection of the skin, first described by Wagner as colloid milium. Hardly more than half a dozen cases of this rare disorder have been reported. It occurs chiefly upon the upper two-thirds of the face, especially upon the cheeks, forehead, and around the orbits; it has also been observed on the cornea and the septum nasi. The lesions form slowly—singly or in groups, never becoming confluent. They consist of pinhead- to millet-seed- or split-pea-sized, flattish, or irregularly rounded lemon-yellow colored papules, having a peculiar glistening, translucent appearance, that suggests their being vesicles, but when pricked only a small amount of a gelatinous substance accompanied by a droplet of blood can be expressed. Occasionally slightly dilated vessels surround the papules. Frequently a depression appears in the center of the papule and increases in depth until the surrounding elevation disappears altogether; all that remains being a slight depression in the skin. Or, the part becoming inflamed, a scab forms over it and eventually drops off, leaving a mark, but no true cicatrix. The cause of the disease is unknown. It occurs in both men and women from the age of sixteen upward, no deviation from the normal health accompanying the disease to account for it. Most of the cases reported were in individuals living an out-of-door life much exposed to the weather.

Wagner at first thought that the cause began in the sebaceous glands, but this view has been practically discarded. Balzer considers that the colloid degeneration commences as an infiltration in and around the connective-tissue fibers and cells of the upper part of the corium. This change occurs especially in the neighborhood of the sebaceous glands and about the vessels and nerves. The glands themselves and all epithelial structures—except the endothelium of the vessels—escape. Balzer could not determine the point clearly, but he thought it probable that the affection was due to primary vascular changes. The disease is not identical with hydradenoma, as Philippson endeavored to prove, though the differential diagnosis is often very difficult or even impossible without the aid of histological examination. From xanthoma, with which it most often is confounded, it may be distinguished by the glistening, translucent appearance of the lemon-yellow colored elevations.

Treatment is unsatisfactory, no external application having any effect. Erosion with a sharp spoon has cured some cases, and electrolysis has been recommended and would seem fitted to cope with the trouble without leaving very marked scars, but freezing with liquid air or if that may not be obtained, carbon-dioxide snow, will effectually remove with the least scar and is by far the best treatment.

CHARLES TOWNSHEND DADE.

**Colloids.**—The term colloid includes all those substances which do not have the power of passing through animal membranes. In contradistinction to this definition stand the crystalloids, those substances capable of passing through animal membranes.

In general the colloids possess a high molecular weight and have little or no influence in raising or lowering the freezing-point, that is, they have a

scarcely measurable osmotic pressure. They do not conduct the electric current, yet they move, for the most part, in an electric current.

Colloids may exist in two states, a liquid and a solid state. The liquid condition is known as a *sol* and where water is the solvent as a *hydrosol*. In a solid state colloids are called *gels*. In the latter condition they may appear as dry, swollen, coagulated masses, as for example, by the action of heat or enzymes, or as precipitated masses through the influence of electrolytes.

Colloids may include acids and bases, as well as the chemical elements and bodies of complex molecular structure like the proteins and starches. It is therefore apparent that from the viewpoint of chemical structure the colloids possess nothing in common. From the researches of Graham it is evident that the colloidal state is dependent upon physical properties.

The colloids are divisible into the following two groups:

(1) *Hydrophile colloids* (emulsion colloids, or emulsoids) are those in which in aqueous solution a certain relation still exists between the dissolved substance and the solvent which is evident especially by a certain viscosity of the solution. Many of the colloids of this group gelatinize on cooling, this modification, the gel, being again soluble in water. As a general rule the hydrophile colloids may be separated from their solution by the addition of electrolytes with greater difficulty than the colloids of the second group. In the group of the hydrophile colloids belong the proteins, starches, and glycogen.

(2) *Suspension colloids*, or suspensoids, include the colloidal metals. They may be looked upon as suspended solid particles in a solvent and do not stand in any direct relation to the solvent. There is no change in the viscosity of such a solution from that of the pure solution and the suspension colloids do not possess the power of gelatinizing nor do they swell. On the other hand, they are readily precipitated by electrolytes. The metallic sols, the colloidal metallic sulphides, and certain typical suspensions obtained by dissolved water-insoluble substances in another liquid, as in alcohol, and then pouring this solution into water, belong to this group. Also suspensions of mastic, colophony, and cholesterol belong in this class.

Colloids are made up of aggregations of particles of various sizes, although the size of the particles differs in different preparations of the same solution. The size of the particles may also undergo a continuous series of changes. Colloidal solutions are opalescent by reflected light owing to the fact that the light is reflected by the particles in suspension. This reflected light is also partially polarized, this property also being dependent upon the presence of small particles in the solution. Tyndall's phenomenon, as this is called, is sometimes employed as a test for colloidal solutions. By means of the ultramicroscope colloidal particles in a solution may be seen. Colloidal solutions may show a quivering motion, first observed by Brown and hence called Brownian molecular motion.

Cataphoresis, that is, the wandering of particles to one or the other poles during the passing of an electric current, is exhibited by some colloids; thus, the colloidal metallic hydroxides wander to the cathode and the other colloids, as the metallic suphides and the acids, wander to the anode. On the other hand, in the dialyzed colloidal protein solutions cataphoresis is absent.

Under a variety of conditions colloids may be separated from their solutions. Some may flock out spontaneously on standing, as silicic acid and the metallic hydroxides, due presumably to their unstable condition. On heating some proteins, for example, flocculent precipitates may be obtained. Other colloids, on cooling their hot concentrated solutions, separate in a more or less solid form containing considerable water, the so-called jellies, or hydrogels, as starch and glue.

The hydrosols may be divided into two groups, (a) the reversible and (b) the irreversible colloids. This classification is made upon the basis as to whether the colloids are again soluble in water after having been dried at ordinary temperature. Starch, dextrin, agar, gums and proteins belong to the reversible group while under the irreversible group are included colloidal silicic acid, stannic acid, colloidal metallic hydroxides and sulphides, and the pure colloidal metals. On the addition of the smallest quantity of electrolyte the irreversible colloids flock out whereas the reversible colloids are relatively non-sensitive in this respect.

Many of the electrolytes are capable of causing a precipitate of colloids. With these precipitating electrolytes a certain minimum concentration is necessary. It has been demonstrated that colloids which wander to the anode are as a rule flocked out by the cations of the precipitating electrolyte and those colloids that wander to the cathode are precipitated by the anions. It has also been shown that the precipitating power of electrolytes is influenced greatly by the valence of the precipitating ions, the greater the valence the greater the precipitation action. Colloids may also be precipitated by each other, for example, proteins may be precipitated by dialyzed iron in the presence of a small quantity of electrolyte. As examples of the influence of electrolytes upon suspension colloids may be mentioned the action of alum upon clay particles in suspension, the behavior of the salts of sea water upon the cloudy fresh water flowing into the sea resulting in delta formation. With the suspension colloids the ability of one to act upon the other to cause flocking out is probably due to the charges of electricity which they carry, for it has been shown that colloids with opposite charges of electricity act precipitatingly upon each other. On the other hand, it is necessary to have a quantitative relationship in order to produce precipitation, for it has been demonstrated that equally charged colloids do not precipitate each other.

Certain of the colloids are called *protective* colloids for the reason that they possess the property of protecting suspension colloids against the precipitating action of electrolytes. As a rule these protective colloids belong to the group of hydrophile colloids and the protection afforded is in the following order, gelatin, isinglass, casein, egg-albumin, gum arabic, Irish moss, dextrin, and starch. The action of protective colloids is explained upon surface tension phenomena. Thus, it is assumed that under the experimental conditions the protective colloid spreads around the particles in suspension like an envelope and in this way the entire mass takes on the properties of the protective colloid and, therefore, is no more sensitive to the precipitating action of the electrolyte than is the protective colloid itself. Most of the protective colloids are precipitated with difficulty by electrolytes. The ability of the protective colloids to prevent precipitation of suspension colloids is expressed in terms of the *gold equivalent*. The gold equivalent is defined as follows: it is the figure in milligrams of colloid which is just insufficient to protect 10 c.c. of gold solution (0.0053–0.0058 per cent.) against the action of 1 c.c. 10 per cent. sodium chloride solution.

Colloids also possess the property of *adsorption*, that is, they may take out of solution certain substances. That the colloids are adsorption bodies is probably due to the fact they are in a finely divided state and may be porous and hence have a great surface energy, the adsorption depending upon changes in the surface tension in an as yet incompletely understood manner. Thus proteins, when

being precipitated, may carry down other bodies in considerable amount and it has been shown that many dyeing processes are to be regarded as adsorption phenomena. (See also *Ferments, Metallic.*)

FRANK P. UNDERHILL.

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**Collyria.**—A collyrium is an eyewash, generally applied with a camel's-hair brush or by means of a dropper. Collyria may be antiseptic, astringent, miotic, mydriatic, or sedative. Salts of lead should not be used, for if the cornea is abraded the lead may be deposited and a black spot will be visible. As a rule astringent collyria should not contain more than four or five grains of the medicine to an ounce of distilled water. The solutions should be as nearly as possible isotonic with the tears. Solutions containing alkaloids will vary in strength according to the physiological action required. There are no collyria official in the U. S. P.

R. J. E. SCOTT.

**Colocynth.**—COLOCYNTHIS. The peeled dried fruit of *Citrullus colocynthis* Schad. (fam. *Cucurbitaceæ*), (U. S. P.). The seeds are to be rejected before using. The colocynth plant is a rough, hairy, tendril-bearing vine, having a general resemblance to the water-melon vine, widely distributed in waste-places in northern and southern Africa and the Levant. It also grows in Spain and other portions of the extreme South of Europe, and has, in addition, been cultivated in several countries for many centuries. Cyprus, the South of Spain, and the African town Mogador, supply it for the market. In the Arabian desert, a resinous extract from the fruit is painted upon the water bags to protect them against attacks by the thirsty camels. The fruit is globular, from two to four inches (10 to 20 cm.) in diameter, with a thin, leathery, mottled-green rind, and a fleshy, very bitter pulp. The latter consists of the mesocarp and three thick parietal placentæ which entirely fill the cavity and make a spuriously three- or six-celled, out of a normally one-celled, ovary.

It is collected when the fruit is ripe, or nearly so, and, in the European varieties, is usually peeled while fresh with a knife. The Mogador colocynth is oftener dried before removing the exocarp. The soft, moist, greenish-white pulp shrivels considerably as it dries, and becomes nearly white, and very light and spongy. The composition and properties differ with the place of production. Some fruits grown in Texas were of prodigious size, but destitute of medicinal power.

DESCRIPTION.—As usually imported, colocynth comes in very light and brittle round balls, from one and a half to three inches in diameter (0.04 to 0.08 meter), composed of a nearly white, very fragile, cellular tissue; evidently cut over the surface with a knife, and containing numerous white or whitish cucumber-like seeds in six rows. These "balls" are easily broken into three parts, each including one of the placentæ, with a row of seeds on each of its two broken faces. The seeds, which, although of little bulk compared with the rest of the fruit, weigh heavily, contain seventeen per cent. of bland fixed oil, and have no medicinal value. They are thrown away when the pulp is prepared for use. This consists of exceedingly large and thin-walled parenchyma, enclosing about two per cent. of its weight of bitter extractive (colocynthin). The variety described above is Turkish colocynth. The Spanish variety is smaller, has a dark and much less spongy pulp and a larger number of heavier, black or blackish seeds. Not only is the percentage of pulp smaller, but it is also inferior. Colocynth pulp, freed from seeds, ground or whole, is an article of commerce. The presence of starch is an indication of adulteration, as this is wanting in the genuine article. The presence of stone-cells in the ground article indicates that seeds were admixed. The presence of these seeds increases the percentage of fixed oil, of which there should be not more than two per cent. present. The ash should not exceed fifteen per cent.

*Composition.*—The active constituents of colocynth are resin and *colocynthin.* The crystalline resinous body *colocynthitin* is not active. Gum and pectin

FIG. 1482.—Colocynth Fruit and Seed.

are also present. Colocynthin ($C_{56}H_{87}O_{23}$?) is a yellow, powdery, bitter glucoside, soluble in both water and alcohol. It is purgative, but Merck claims that his is not poisonous or drastic like colocynth.

ACTION.—Colocynth itself is a harsh and irritating drastic, and seldom given alone. In small doses, and modified by other cathartics and corrigents, it is an excellent laxative, and in frequent use as a "dinner pill" in chronic constipation.

ADMINISTRATION.—There is but one immediate preparation, namely, the Extract of Colocynth (*Extractum Colocynthidis*, U. S. P.), made by evaporating a tincture. The yield is about sixty per cent. of the pulp. Dose, say gr. ss.–ij. (0.03–0.12). It is seldom used alone, but enters into the Compound Extract of Colocynth (*Extractum Colocynthidis Compositum*, U. S. P.), which is in every-day use. Its formula is:

| | |
|---|---|
| Extract of colocynth | 16 |
| Purified aloes | 50 |
| Cardamom | 6 |
| Resin of scammony | 14 |
| Soap | 14 |
| Alcohol | 10 |

It is a fine powder, easily rolled into a pill itself, or mixed with still other substances. Dose, as a laxative, gr. iij.–v. (0.2–0.3), as a cathartic, five or six times as much gr. v.–xxv., (0.3–1.6). The Compound Cathartic Pills (*Pilulæ Catharticæ Compositæ*, U. S. P.) contain about one-third of their weight of this extract. Their composition is:

| | Grams. |
|---|---|
| Compound extract of colocynth | 80 |
| Extract of jalap | 30 |
| Mild chloride of mercury | 60 |
| Gamboge | 15 |

Mix and make 1,000 pills. Dose, from one to three pills.

The compound extract is also an important ingredient of the official vegetable cathartic pills.

Pure colocynthin can be given in doses of gr. $\frac{1}{6}$ to $\frac{2}{3}$ (0.01–0.04). A resinous extract is also in the market under the name colocynthin.

Merck recommends, as a purgative rectal injection, ♏ iv. to xv., (0.25–1.0) of a four-per-cent. solution of colocynthin in equal parts of glycerin and alcohol.

HENRY H. RUSBY.

**Colombo, Matthæus R.**—In his youth, in the early part of the sixteenth century, Colombo lived in Cremona, on the river Po, Northern Italy; a certain portion of this period of his life being spent in the apothecary business. Then he studied surgery under Plazzi, and later still he became the pupil and intimate friend of Vesalius, the anatomist, at Padua. In 1543, when this great man was called to Madrid to be the First Physician of the Emperor, Charles V., Colombo was appointed his successor in the university. In 1546 he was made Professor of Anatomy in the University of Pisa; but he remained only a short time in that city, as the Pope, Paul IV., wanted him to occupy the same Chair in Rome. He died in 1559.

Colombo, according to the account of his life given by Dezeimeris, unquestionably possessed the true genius of the anatomist; his descriptions of different parts and structures of the human body being characterized by a wonderful degree of clearness and precision, by orderliness, and by thoroughness in regard to details.

Colombo's great work on anatomy bears the following title: "De re anatomica libri xv., Venice, 1559." (An edition was published at Frankfort as late as 1599.) Among other things he describes the manner in which blood-vessels penetrate into the substance of a bone; he was acquainted with the three ossicles of hearing, and considered himself the discoverer of the stapes; he gives a perfect description of the vertebræ and of their connections; he is the first anatomist whose description of the ventricles of the larynx is really satisfactory; and, finally, he is entitled to the honor of being the first anatomist whose description of the pulmonary circulation is correct. This description reads as follows (as translated from the French version of Dezeimeris): "When the heart undergoes dilatation, the blood passes from the vena cava into the right ventricle; from this ventricle it is forced into the arterial vein which transports it to the lung, where it is thinned and mixed with air. From the last-named vessel the blood passes into the venous artery, the function of which is to carry the blood (mixed with air by the action of the lung) into the left ventricle of the heart. Then, the heart contracts, the tricuspid valves are lifted up into place and thus present an effectual dam against the return of the blood into the vena cava and into the pulmonary veins. At the same time the valves which are located at the entrance of the venous artery and the aorta fall back and permit a free passage to the blood which is entering the heart, as well as to the blood which immediately afterward is to be sent coursing on its way throughout every part of the body." This explanation, says Dezeimeris, is certainly more precise and more luminous than that which was given by Servetus with regard to the pulmonary circulation.

A. H. B.

**Colon, Anatomy of.**—See *Digestive Tract.*

**Colon Bacillus Infections.**—In this article it is proposed to call attention to the various conditions which infection by the colon bacillus may produce, in some cases simulating other diseases; and hence the serious errors in diagnosis which may result unless we consider the possibility of this type of infection. Doubtless in a large percentage of cases the selective point of infection is in the urinary tract. Infection occurs elsewhere, however, with considerable frequency. Fortunately in the majority one can determine the source of the trouble by the discovery of colon bacilluria, even though there be no urinary symptoms. Though Murray and Williams[1] report that colon bacilli are present in normal urine in 44.5 per cent. of gynecological cases before operation, this does not mean that the colon bacillus is a normal inhabitant of the urine. A temporary bacilluria may occur with no or with slight symptoms, due to the resistant powers of the patient. The presence of colon bacilli in the urine is a *pathological condition*, may produce serious results at any moment, and, in my opinion, calls for immediate treatment.

Urinary Tract.—Colon bacillus infection of the urinary tract is the most common type. The modes of infection are (1) Ascending infection, through the urethra; (2) Descending (through the blood stream); and (3) Infection by contiguity.

*Urethral Infection.*—With ascending infection, the bacillus coli enters the urinary tract by way of the urethra. The greatest number of cases apparently occur among females, due, it is believed, to the short urethra and its proximity to the vulva and anus, rendering contamination easy. In the male, Melchior claims to have found the colon bacillus in the meatus in fifty per cent. of cases examined, and others have demonstrated it on the foreskin. There is, moreover, the possibility of the bacillus being carried into the bladder by instrumentation, such as by catheterization.

It has been demonstrated by Bond[2] on postoperative cases that there is an ascending current from the urethra to the bladder and thence to the kidney. The possibility of its occurrence in health is suggested. This upward current was more marked when there was an obstruction to the urinary outflow, which suggested that disease of the urinary tract, interfering with micturition, would render infection more easy. It is also well known that kidney infection frequently follows transplantation of the ureter into the intestine.

The lymphatics and blood-vessels of the ureter may also furnish the port of entry to the infection.

*Hematogenous Infection.*—Infection through the blood stream, the writer believes to be the most common cause, *i.e.* so-called "descending infection." There is most frequently a solution of continuity, or ulceration in the intestinal tract. The writer has seen such infection in association with typhoid fever, intestinal ulcer, and intestinal catarrh; and in one case constipation was an apparent factor for the passage of the bacilli.

Infection through the blood can also occur, *excluding blood infection from the intestines.* As an example of hematogenous infection extraneous to the intestine, tonsillitis is believed to be the source of infection of some cases, and Rovsing[3] refers to such cases. The writer has recently seen a recurrence of colon bacilluria following tonsillitis in a patient who for six months had no colon bacilli in the urine.

In this connection it is interesting to note the effects of colon bacilli on the liver. E. L. Opie[4] in his experiments has shown that bacteria in association with toxic substances having a special affinity for the liver, such as chloroform and phosphorus, may produce changes which neither the poison nor the bacteria can cause when acting alone. The possibility that disturbances of metabolism in the human being may produce changes in the liver similar to those caused by such poisons is well known in the toxemia of pregnancy. Moreover, bacterial infection may influence and even determine the development of cirrhosis of the liver. Degenerative changes which usually undergo rapid repair may cause sclerosis when combined with bacterial infection.

By the administration of chloroform, accompanied by intravenous inoculation with *Bacillus coli*, it has been possible to produce advanced hepatic cirrhosis, accompanied by an active new formation of bile ducts, within a period of twenty-three days.

This experimental work suggests the explanation of how some alcoholics escape cirrhosis, while temperate persons and even total abstainers develop the disease. In the later cases one must assume that the toxic element arises from the production of poisons inside the body.

Adami refers to infectious cirrhosis of the liver produced by colon bacilli and Metchnikoff believes that the products of their growth produce liver cirrhosis and arteriosclerosis.

*Infection by Contiguity.*—Bacteria can pass from the intestines into the lymphatic spaces even though there is only a slight lesion of the intestinal wall, and undoubtedly some of the intraabdominal masses due to colon infection result thereby. Colon infection of the pancreas may occur through the lymphatics of the pancreatic duct as well as through the blood stream or duct channel. This is also true of the common bile duct and gall-bladder.

Direct rupture of a colon bacillus abscess may also occur in some part of the urinary tract. It is interesting to note that Franke[5] has shown that in rabbits there is a lymphatic connection between the cecum, ascending colon, and right kidney, but he has not demonstrated it on the left side. With a solution of continuity in the gut, right renal infection would be easy, according to his view.

The colon bacillus has a definite relation to certain infections in the gastrointestinal tract. For example, it has been found as a factor in acute appendicitis, and also in the fluids of acute peritonitis. It has been responsible for inflammation of the pancreas and gall-bladder; and colon bacilli have been found as the nucleus of gallstones and pancreatic calculi.

Furthermore, Fenton B. Turck has fed colon bacilli to dogs and has experimentally produced gastric ulcer in these animals; and in the Mayo clinic, Pilcher has found colon bacilli in cases of achlorhydria hemorrhagica gastrica.

R. T. Morris believes the colon bacillus entering the terminal vessels of the duodenum may in some cases be responsible for ulceration of that viscus. The writer refers to such a case in his work on Diseases of the Stomach, Intestines, and Pancreas, 2d. Ed., p. 684. Acute gastric ulcer complicating appendicitis might result from the same source.

Herter's investigations into intestinal putrefaction show the influence of the Bacillus aerogenes capsulatus in the production of pernicious anemia. The possibility that this last condition may at times be the result of colon bacilli infection is suggested by A. Charlton in his researches at McGill University, in an article entitled,[6] "On the Anemia Produced by Repeated Injections of Cultures of a Colon Bacillus of Low Virulence." Striking results followed intravenous injections, the experiments being carried on for many weeks. They were as follows: Advanced anemia occurred, in some respects like the condition found in pernicious anemia, namely, a great diminution in the number of red cells, marked poïkilocytosis, the appearance of pear-shaped cells, crescents, macrocytes, microcytes, and, lastly, nucleated red cells. On suspension of the injections for some weeks even when the fall of erythrocytes was from five and a half to only one and a half millions, spontaneous recovery took place. When injection of the bacilli was resumed, the injurious results were more marked than before, but in addition to the effects on the blood, strikingly progressive changes were produced in the spinal cord, consisting of diffuse degeneration in the columns of Goll and in the anterolateral columns of the cord, closely resembling the conditions of the spinal cord in some cases of pernicious anemia.

Adami refers to anemia produced by infection with the colon bacillus and another observer has found on several occasions that the blood in methemoglobinemia was infected with this organism.

H. G. Harris,[8] of New York, has reported an interesting and unusual case of infantile paralysis in which colon bacilli were found in large number in the urine. The patient recovered under the use of urotropin and lumbar puncture. In view of the changes produced in the spinal cord experimentally by the injection of colon bacilli into the circulation, the clinical case cited is of interest.

Infection Produced by the Colon Bacillus.—Among the types of infection produced by the colon bacillus are acute, subacute, and chronic nephritis—which have been admirably portrayed by Dr. Wm. Hanna Thomson[9] in a recent article. Pyelitis, pyelocystitis, pyelonephritis, septic infarcts of the kidney, cystitis, pneumaturia, and enuresis may result from colon bacillus infections. Attacks of intermittent fever, the fever coinciding with the appearance of colon bacilli in the urine, and the intermission, with their disappearance, have been reported. Acute meningitis, abscess of the brain, otitis, prostatitis, and seminal vesiculitis are reported due to colon bacillus infection. In some cases the colon bacilli are responsible for malignant endocarditis. Their relation to appendicitis and peritonitis are well known.

In view of the frequency of appendicitis or gall-bladder infection in association with gastric or duodenal ulcer, the writer believes that ulceration, in some cases at least, may be imputed to the colon bacilli or their toxins. In this connection the presence of gastric erosions and colon bacilli in the gastric contents, in cases of achlorhydria hemorrhagica gastrica, and dependence of the latter, in many cases, on appendicitis or gall-bladder infection, are more than worthy of a passing mention. Schottmüller has recently reported some fifty cases of facial and oral herpes in women suffering from pyelitis, cystopyelitis, and postoperative puerperal processes, the latter conditions due to colon bacillus infection. No colon bacilli were found in the herpetic process, and it was believed to be due to bacterial toxins. An analogous condition occurs in pneumonia.

Robert T. Morris holds that the mild types of intestinal adhesions result from the toxins of intestinal bacteria, the colon bacillus among them. The writer believes that in many cases of more marked adhesions, colon bacilli will be found to be present. For example, intraabdominal exudates and tumors, thought to be tuberculous or carcinomatous, have been demonstrated to be due to pure colon bacilli infection.

Cases simulating pernicious anemia may be due to the same cause.

Choroiditis has also been reported as due to this infection. The author has described a case, private patient at the New York Hospital, who was under his care, who suffered from general infection with the colon bacillus. This patient had a double pyelitis, cystitis, double pneumonia, purulent bronchitis, two attacks of colitis and myocarditis, all in succession, and ultimately recovered. Colon bacilli were present in the urine and sputum in enormous numbers. Infection of the respiratory organs by the colon bacilli is comparatively rare.

Wound infection by colon bacilli may also occur.

Subdiaphragmatic abscess has also been reported as due to this infection. Acute cholecystitis, cholangitis, or gallstones are not an uncommon result. The writer believes acute suppurative pancreatitis, and at times acute gangrenous pancreatitis may be due in part to this type of infection. Pancreatic lithiasis may be dependent upon it, and he recently treated a case of undoubted chronic interlobular pancreatitis, with steatorrhea, with a loss of forty pounds weight in two years, diarrhea, and colon bacilli in the urine. There was a previous history of duodenal ulcer apparently cured. I believe the interstitial pancreatitis was in part the result of the colon infection attacking the pancreas, just as cirrhosis of the liver was experimentally produced by Opie.

The colon bacillus has also been responsible for an epidemic giving the clinical symptoms of typhoid fever. It has been mistaken for influenza. I can remember one case of infarcts of the right kidney due to these organisms. Finally chronic arthritis due

to colon bacilli has been reported. The symptoms present much resembled gonorrheal infection of the joint.

*Urine.*—The urine of colon bacilluria, unlike other urines which are decomposed by the bacteria giving an alkaline reaction and an ammoniacal odor, remains *strongly acid*. Wm. H. Thomson and Howard Kelly emphasize this feature, and also that the same acid reaction is found with tuberculosis of the urinary tract.

Dudgeon states that the common reaction of the urine is acid, but that it is more often alkaline than might be supposed. Acid urine is certainly the usual finding with colon bacilli at the time the examination is made for diagnosis.

I have subsequently seen the urine neutral after the ingestion of large quantities of water, and, of course, alkaline after the use of alkalis. In mild cases, the urine may appear quite clear, yet colon bacilli are found to be present; in more marked cases, there may be varying degrees of turbidity, and often the urine has an opalescent appearance with a faint mucous cloud.

Pyuria of varying severity is present; occasionally casts, and also epithelial cells and the colon bacilli (Gram-negative under the microscope). Cultures should be made to confirm the diagnosis.

In cases of acute nephritis due to colon infection, albumin, casts, and blood are present.

Symptoms of Colon Bacillus Infection.—On account of the diversity of these infections, it seems best to the author to illustrate them by various cases. Acute infection of the kidneys will be first described.

An interesting case is reported by Wm. H. Thomson in consultation with Robert Abbe.[10] On the fifth day after the operation for pelvic tumor, the patient complained of cramps and pain in the abdomen, extending to the rectum, accompanied by nausea and frequent vomiting, followed by a rise of temperature to 104.3° F. She then became drowsy and apathetic, with muscular twitching in the face and upper extremities. The wound was healthy and healed by first intention. These symptoms cleared up. On the twenty-second day after the operation, the patient had slight chills, lasting twenty minutes, rise of temperature to 103.5° F. again with the development of the symptoms described above. In addition, the pulse became rapid, small, and irregular. The following day the urine became loaded with pus, blood and casts. Colon bacilli were found in large numbers. On account of the vomiting, urotropin and sodium benzoate were administered by rectum every three hours. As the patient also had oliguria, enteroclysis with Kemp's tube was ordered forenoon and afternoon with two gallons normal saline solution; the urine rapidly increased in quantity and thereafter averaged from 60 to 112 ounces in twenty-four hours.

During the course of a week the pus and blood cleared up. The urine continued acid with specific gravity averaging 1008, but still showed a diffused white cloud. This is characteristic and is caused by immense numbers of colon bacilli in suspension. The cerebral symptoms and vomiting ceased within twenty-four hours after initial treatment, and the temperature fell to 99° F. and thence to normal. The bacilluria still persisted until on the twenty-eighth day the patient developed symptoms of subacute appendicitis. Abbe operated under local anesthesia and removed a diseased appendix with several hemorrhagic points in its lumen and a large ulcer in its base in the cecum. The bacilli subsequently disappeared from the urine. Though the treatment alleviated the severe symptoms the focus of infection was present until removed.

Chas. R. Box, of St. Thomas's Hospital, London, in an article in the *Lancet*[11] observes that in many cases where the kidneys are involved in *typhoid fever, scarlet fever, measles, and diphtheria*, the *organism* found in the *urine* is the *colon bacillus*.

The writer has seen several cases of acute nephritis in the course of *typhoid fever*, due to colon bacillus infection. In one case, the patient having suffered from many of the complications of typhoid fever, suddenly on the eighty-fifth day of the disease developed severe chills, with rise of temperature and marked oliguria. Albumin, blood, casts and numerous colon bacilli were found in the urine. The patient rapidly developed pulmonary edema and died within a few days. The symptoms just noted are suggestive of this condition when occurring late in typhoid fever. Delirium may be associated.

An interesting case of A. Seibert's of New York, during the course of scarlatina, has been reported by Dr. Thomson. "The girl, aged eleven, in the sixth week of her illness was suffering from universal edema, most marked in the face, some cystitis, pulse 48, intermitting every third beat. She was semi-conscious, with total blindness which had persisted for five days, nausea and incessant vomiting which had lasted for ten days, necessitating rectal feeding. Two severe uremic convulsions had occurred on the previous day. Only four or five ounces of urine had been passed in the previous twenty-four hours, and this contained but a moderate amount of albumin. Urotropin gr. v. dissolved in ℥j. cold water with fifteen drops of dilute hydrochloric acid was administered and retained. The same dose of urotropin was continued every three hours. The headache first disappeared, marked diuresis set in so that 110 ounces of urine were passed in the next twenty-four hours and all edema disappeared within forty-eight hours. The amaurosis diminished in two days and finally disappeared in a week, after which she made an uninterrupted recovery."

Unquestionably ulcerative conditions of the intestines, notably of the colon or rectum, or simple solution of continuity of the mucosa furnish a ready source of entrance to colon bacillus infection, and acute or subacute nephritis may result, due to this bacillus. Undoubtedly after operation on the intestinal tract *some cases of so-called "postoperative nephritis" may be imputed to this cause.*

Chronic Interstitial Nephritis.—William H. Thomson holds that this condition may be primarily caused by slow infection of the kidneys by the *Bacillus coli*. Sudden terminations of cases of chronic interstitial nephritis, characterized by oliguria or suppression of urine, are nearly always preceded by acute indigestion in some form, and he always dreads an attack of so-called "cholera morbus" in an elderly patient, and at once examines the urine.

These cases are frequently attributed to an acute exacerbation of the chronic kidney disease, whereas he has saved a number of such cases by immediate resort to urotropin and sodium benzoate, administered by rectum when the patients were comatose.

The writer in his work on "Diseases of the Stomach and Intestines," under "Indicanuria," has called attention to the acute kidney disturbance produced by intestinal putrefaction as evidenced by marked indicanuria, and has noted the value of urotropin and sodium benzoate for the treatment of this condition.

Cholecystitis.—Inflammation of the gall-bladder is frequently produced by the colon bacillus, which may reach it, probably most frequently through the gall-duct, or at times through the blood stream or lymphatics.

At the Johns Hopkins Hospital, the gall-bladders of animals were infected with the colon bacillus, and subsequently cured, or inflammation prevented, by the administration of urotropin. It would seem wise to examine the urine for the colon bacillus in all such cases. In any event, urotropin would be of value to disinfect the gall-bladder.

Acute invasion of the kidneys by the colon bacillus may be productive of a pyelitis, usually bilateral. First, one kidney is attacked; and after subsidence of acute symptoms, then the other organ. There is again a subsidence of the symptoms, but recurrences usually take place in one kidney and these continue until final cure. There is a sudden rise of temperature, 103°–105° F., often preceded by a chill, first one and later frequently the other kidney becomes tender on pressure, there is pain in the lumbar region, urine is highly acid, contains pus, occasionally blood, and is loaded with colon bacilli. L. C. Dudgeon, in his Erasmus Wilson Lecture on "Acute and Chronic Affections of the Urinary Tract,"[12] also describes such cases. He reports that such attacks sometimes occur with appendicitis. As a matter of routine, the author believes that in all cases of pyelitis one should examine the urine for colon bacilli. Pyelitis with an acid reaction of the urine is at once suggestive of colon bacillus infection. The dose of urotropin usually given is too small, as will be described under treatment.

Pyelonephritis from colon bacillus infection occurs at times during pregnancy, constipation being a factor. Direct postpartum conditions are particularly favorable for this form of infection, the rectum being at times torn and frequently the seat of abrasions from stretching, and the urethra, vagina, etc., suffering traumatism.

Enuresis, occurring among children, may be found to be due to colon bacillus infection.

Cystitis may occasionally occur from the same source, though more usually the difficulty lies higher up—a pyelitis with irritable bladder associated.

George E. Brewer[13] reports several cases in which the lesions were confined to one kidney. One of these patients was referred by the writer. This condition may be due to pure cultures of the *Staphylococcus pyogenes aureus*, virulent forms of streptococci, and there was one case of his in which the organism was the *Bacillus coli*. Other authors mention the latter as a frequent cause of this condition. The symptoms, which are sudden in their onset, are chills, a temperature rising rapidly to 103°, 105°, and even to 106° F., tenderness over the kidney, especially at the costovertebral angle (Brewer's point). Pus, albumin, casts and at times blood are present in the urine.

Infarctions may occur in both kidneys.

Differential ureteral catheterization will determine whether one or both organs are involved. The Gram-negative bacilli are present in the urine. Cultures should also be taken.

Choroiditis.—Robert T. Morris reports the case of a patient referred to him by John S. Kirchendall, of Ithaca[14] who suffered from choroiditis which threatened to end in blindness. Morris found that for years the patient had suffered from intestinal trouble due to fibroid degeneration of the appendix, and on its removal the patient recovered both from the intestinal dyspepsia and also from the choroiditis.

Pelvic Exudate and Intraabdominal Tumors due to Colon Bacillus Infection.—F. Charlton Briscoe,[15] physician to King's College Hospital, London, relates several instances of the matting together of the pelvic viscera by an exudate showing caseous changes which led to a mistaken clinical diagnosis of tuberculous nature, but which proved on microscopical examination to be caused by the *Bacillus coli*. In such cases colon bacilli were found abundantly in the urine. In one patient the mass simulated a carcinoma.

Briscoe further refers to an interesting number of cases which have attacks of intermittent fever, the temperature coinciding with the appearance of colon bacilli in the urine and the intermissions with their disappearance. He advises that the urine be examined for the colon bacillus in all cases of febrile attack of obscure origin. He also notes how frequently ulcers in the rectum occur previous to invasion of the kidneys and other organs. He, together with other authors, comments on the pale color of the urine, its milky haze, acid reaction, and high specific gravity, together, with the chronic persistence of the colon bacilli when they once appear in the urine. He also notes that the urine never decomposes with an ammoniacal odor.

Briscoe makes the urine alkaline, gives frequent mercurial purges, and administers autogenous vaccination, the initial dose being 50,000,000 of the dead organisms every seven to eight days, with effective results. Rawls[16] refers to infection of the respiratory organs by the colon bacillus, but few cases have so far been reported. Ulcerated hemorrhoids were the source of infection in one of the writer's cases.

Finally, the author desires to refer to a case of general infection with the colon bacilli, in which the organisms were found both in the urine and in the sputum. The patient, age forty-four, was operated on at the New York Hospital by Dr. Frank Hartley, for right inguinal hernia. The subsequent complications were as follows, all due to infection with the colon bacillus: double pyelitis, cystitis, double pneumonia, purulent bronchitis, two attacks of colitis, and a myocarditis.

March 2, 1910, operation by Frank Hartley for right inguinal hernia of rather small size. Two days after operation a pyelitis occurred in the left kidney followed by an attack in the right kidney. Urotropin in doses of gr. x, t.i.d. was administered. A week later pneumonia developed to which the patient nearly succumbed.

March 19, some increase in temperature, showing farther involvement of the base. Temperature at no time very high. After two or three days it gradually defervesced. At midnight, March 24, the patient was suddenly taken with an extremely severe chill, lasting about one-half an hour, and the respirations rapidly increased. The temperature shot up to 104° F., dropped to normal, and then gradually rose to 101° to 102.5°. Drs. F. Hartley and S. Lambert saw the case in consultation and, suspecting the possibility of complicating empyema, or subdiaphragmatic abscess, Hartley put aspirating needles in several locations—pleura and liver—with negative results.

As there was no apparent cause for this condition, and as the pyelitis was still in evidence, the writer having seen a number of cases of colon bacillus infection with the same type of chill noted in this case, requested an examination of the urine for this organism; and on suspicion increased the urotropin to gr. x every three hours, adding sodium benzoate equal amount. In the morning a large number of Gram-negative bacilli were reported under the microscope. The urotropin, gr. x., and sodium benzoate, gr. x., were continued every three hours, both day and night, a total of eighty grains each per day; and later pure cultures of colon bacilli were reported in the urine. The temperature gradually defervesced to about 99.5°, where it remained.

Resolution of the right lung was very slow, little expectoration, but abundant colon bacilli were found in the sputum.

In early May there was a sharp attack of colitis, no blood or occult blood could be found. Irrigations of the colon with acetozone, 1–1000, and lactic acid bacilli tablets were begun and kept up thereafter.

Subsequently a second pneumonia occurred at the left base, very slight, mild symptoms, temperature slight, no cardiac disturbance but slow to resolve. Undoubtedly, the saturation of the patient with urotropin was contributory to its mildness. Colon bacilli were again found in the sputum. Blood cultures taken at this time and found sterile.

In May there was a sudden attack of acute purulent bronchitis. So thick was the pus that a pulmonary abscess was feared. Culture showed enormous numbers of colon bacilli and some streptococci. Beyond during the initial few hours, no especial discomfort

occurred, except from the cough. Autogenous vaccines were then begun, one billion to one c.c. One minim was first administered by hypodermic, this continued daily for several days, and then gradually increased one-half minim per dose up to the maximum, of five minims.

The bronchitis improved, but there was no disappearance of the bacilli from the urine, though the vaccines were given daily. At the end of May, the general condition of the patient had so improved that he was removed to his home. After three weeks, administration of vaccines caused marked reaction, so they were stopped.

In June an exacerbation of pyelitis occurred and a second attack of colitis coincident—a very suggestive circumstance. Again the stool was examined for pus and occult blood, as ulcer was suspected by the writer, but the results were negative. The author is, however, fully convinced that the colon bacillus infection was autogenous from the gut.

In June, autogenous vaccines were again administered, 200,000,000, and about a week later 300,000,000. Considerable reaction followed these injections, which alarmed the patient. They were discontinued and reliance placed on the urotropin and sodium benzoate.

In July there was only a slight evening temperature, 99° to 99.5°, bacilluria persisting, with few pus cells. There was still a slight evidence of unresolved pneumonia at the left base, no cough. He suffered some shortness of breath on exertion, and the heart action was somewhat rapid, a myocarditis of mild degree, due chiefly to the toxemia, in the author's opinion. Iron, strychnine, and arsenic were given for the cardiac condition. On August 7, the colon bacilli disappeared, there being only a few pus cells found thereafter. The urine remained free from colon bacilli until October, 1910. On the first of that month, the patient returned to the stock exchange, and against advice persisted in full days' work. On about the fourth day he had slight chilly feelings, slight rise of temperature, and reappearance of the colon bacilli in the urine, though not in great numbers. These gradually diminished under dosage of urotropin fifty to sixty grains daily.

The patient in October went to southern France. On December 24, 1910, he wrote that his temperature remained normal and only a few colon bacilli persisted in the urine. Before October 1, he had regained his loss of weight, which was thirty-five pounds.

Urotropin, eighty grains, with sodium benzoate, eighty grains, were given daily from March 25 to June 1. From June 1 to July 7 urotropin averaged sixty grains daily. Up to May 1, no irritation resulted from the treatment. Sudden changes in the urinary reaction then occurred and there was considerable difficulty in controlling the irritation. It would be extremely acid at one time and very alkaline later, both conditions causing irritation. The writer finally secured the best results at this later period by keeping the urine neutral or faintly acid, stopping the benzoate when there was excessive irritation with marked acidity and giving an alkali with the urotropin.

On the other hand, when alkaline urine with irritation occurred, sodium benzoate was given. The urine was carefully watched for the presence of casts and cylindroids, but no evidences of renal irritation from the urotropin could at any time be discovered.

From July 7 to August 7, urotropin, fifty to sixty grains, was administered daily.

From August 7 to October 4, urotropin was reduced to forty, thirty- and finally to twenty grains daily, the latter as a prophylactic. In spite of this, the colon bacilli reappeared in October. It was interesting to note that the thirty grains daily urotropin given for the initial pyelitis did not prevent the nearly fatal pneumonia, and that the large doses of eighty grams daily did undoubtedly prevent severe symptoms during the subsequent second pneumonia and purulent bronchitis. The autogenous vaccination evidently was of some value to relieve the clinical symptoms of the bronchitis, but the disappearance of the bacilli occurred following the persistent use of urotropin. There was considerable reaction toward the end of the first period of autogenous vaccination, and unpleasant symptoms, rise of temperature, pain in one kidney, etc., followed the second period.

In early January, 1911, the patient reported to me that colon bacilli had disappeared from the urine. On May 1 he returned to New York and resumed his business. The urine remained free from colon bacilli until some time in July (over six months) when the patient had a sudden attack of tonsillitis, and immediately there was a recurrence of colon bacilli in the urine. Urotropin was given, sixty grains daily. He remained away from business a few days. Medication was gradually reduced, and in the report of October 12, 1911, only a few colon bacilli were found in each field, fifteen grains urotropin being now taken daily. By January, 1912, the colon bacilli disappeared from the urine and did not again appear until June, 1913. Colon bacilli are still present in October, in spite of vigorous treatment.

During the free periods, the last one of over six months, most of the time about ten to fifteen grains urotropin were taken as a prophylactic, and one attack followed tonsillitis. The vaccines relieved symptoms, but the urotropin eventually cleared the urine. It also, the writer believes, lessened the severity of the second pneumonic attack. The small doses of urotropin, thirty grains daily, were useless, a nearly fatal pneumonia from colon bacillus infection occurring during the administration of this dosage for pyelitis. Large doses, preferably eighty grains daily, as suggested by Wm. H. Thomson, must be given to produce effects, and the sodium benzoate is a valuable adjunct.

It has been claimed that the ingestion of *Bacillus coli* by the leucocytes is much more active in an alkaline than in an acid media, and it is advocated by many to render the urine alkaline and less irritating.

It is also stated that urotropin is valueless if the urine is alkaline and that no formaldehyde is given off. On investigation the writer finds that some formaldehyde is eliminated in an alkaline urine, though less than in an acid medium, and that the urotropin itself is a urinary antiseptic.

Finally, I wish to call to the reader's attention that in addition to the marked indicanuria in intestinal obstruction, colon bacilli infection may also occur. The possibility that gastric hemorrhage, as a complication of acute appendicitis, may be the result of an infarction from colon bacillus infection carried to the stomach with bleeding from an acute ulcer is worthy of investigation, especially in view of Turck's experiments.

Diagnosis.—The urine should be examined for Gram-negative bacilli, and cultures should be taken. An acid urine pyelitis is due to colon bacillus infection or tuberculosis. Cultures should be taken in cases of wound infection, from tumors, etc., whenever this condition is suspected.

Treatment of Infection by the Bacillus Coli.—In my own experience final cure of my patients was secured only by the persistent use of urotropin and sodium benzoate—in large doses during the acute stages, eighty grains of each daily, subsequently diminishing the dosage. I know of one case, acute meningitis, in which as much as 120 grains of urotropin was given in divided doses during twenty-four hours for several days, with successful results. I have information of another case where 240 grains was given for a period of twenty-four hours. Renal irritation with blood in the urine resulted. This immediately cleared up on stopping the urotropin. If renal congestion occurs at any time from pushing this

remedy, stop administration for twenty-four hours, give cream of tartar lemonade, and return to smaller dosage. Hexamethylenamine I have found not as satisfactory and more apt to derange the stomach. I do not believe it as strictly standardized as the German preparation.

The general treatment may be summarized as follows:

(1) Urotropin and sodium benzoate āā gr. x every three hours by mouth; *by rectum, if there is vomiting or coma.* Total eighty grains of each daily.

After prolonged use, if there is excessive acidity with irritation, omit the sodium benzoate and give Vichy or potassium citrate with the urotropin.

Subsequently regulate the urine so as to be neutral or faintly acid. Diminish dosage as condition improves.

(2) Autogenous vaccines, especially if the infection is chronic, or does not respond to treatment, are of value. Begin with 100,000,000 of the vaccine bacilli, increasing to 300,000,000 to one billion, gradually, first every two or three days, or larger doses at longer intervals—four to seven days. I have seen the vaccines improve the clinical symptoms, but they did not eradicate the colon bacilli. The urotropin proved successful in this regard.

(3) Lactic acid bacillus cultures should be given internally, preferably the liquid, three to six tubes daily. I generally employ these in the subacute and chronic cases. Several hours should elapse between the urotropin and lactic acid bacilli preparations.

(4) High enemata, 1–1,000 acetozone, every day, and later every other day.

(5) Sour milk diet, later cereals, etc. Avoid red meats.

(6) Bowels should be opened at once by calomel or blue mass, and then regulated carefully every day.

(7) Dudgeon recommends the use of antibacillus coli serum in doses of 25 c.c. spread over seventy-two hours, but so far the method has not been sufficiently tried to recommend it.

After recovery from the acute infection, one must remember that colon bacilli infection is characterized by chronicity and by tendency to recurrence.

ROBERT COLEMAN KEMP.

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**Colon, Congenital Dilatation of.**—Synonyms: Idiopathic dilatation of the colon; Dilatation and hypertrophy of the colon; Megacolon congenitum; Hirschsprung's disease; Congenital inertness of the colon; Neuropathic dilatation and hypertrophy of the colon.

*Historical.*—According to Nothnagel this disease has been described for over fifty years. In 1880 the condition was carefully studied by Hirschsprung, of Copenhagen, so that in Germany the disease is generally known by his name. Kredel in 1904 collected seventy cases from the literature, and recently Hawkins (*British Medical Journal*, March 2, 1907, p. 477) has described nine cases ranging in age from three weeks to forty-eight years. Quite a literature of the subject has accumulated, the most important contributions being those of Hirschsprung, Concetti, Gourévitch, Netter, Ibrahim, Marfan, Kredel, Hale White, Fenwick, Richardson, Treves, and Hawkins. Finney in 1908 reported eleven cases from the Johns Hopkins Hospital.

*Definition.*—The condition may be perhaps best defined as a dilatation and hypertrophy of the lower segment of the colon or sigmoid flexure. It is not due to any mechanical obstruction, but probably to congenital deficiency in the innervation of the bowel. In most cases the dilatation depends upon a paralytic condition of the bowel, but in rare instances a condition of spasm has been found. A few of the cases which have been recorded as examples of this condition are really instances of fecal impaction leading to great dilatation of the colon behind the impacted mass.

*Symptoms.*—The condition occurs more frequently in males than in females, at all ages, and the cases may be divided into the following groups: I. Cases in which at birth or the first days of life there are obstruction and distention of the abdomen. II. Cases in which the condition develops a few months after birth, mostly at the time of weaning or of adding solid food to the diet. III. Those that develop some years after birth. IV. Cases in which the symptoms develop in late adult life, usually between forty-five and fifty-five years of age.

Group I.—In an infant born with no evident abnormality the condition is revealed by the fact that there is no spontaneous passage or meconium. On examination with the finger no mechanical obstruction can be found. Enemata bring away a small quantity of meconium. The child is restless, sleeps poorly, has no defecation without assistance; then distention of the abdomen appears. The abdomen becomes hard, its skin covered by dilated veins, and there is perhaps also some edema. Dyspnea and cyanosis may supervene. If irrigations are given, only the water returns, but following the insertion of the finger into the rectum, especially if massage of the abdomen is practised at the same time, a large quantity of meconium or feces is passed. As the abdomen diminishes in size, the child's general condition improves, it begins to take its feedings which formerly were refused, the cyanosis diminishes, and the baby is comparatively well. Later on, the whole series of symptoms is repeated time and time again until death ensues. The cause of death is either failure of the respiratory organs, inanition, or chronic intoxication from the absorption of decomposition products from the intestine. If intoxication exists there are apt to be coma, convulsions, and meningeal symptoms. This group of cases comprises those that are designated Megacolon congenitum.

Group II.—These are cases in which during early infancy the general health was good and the function of the bowel either normal or there was only slight constipation. At the time of weaning or of beginning solid food, obstinate constipation appears, then distention of the abdomen and the development of the balloon shape to the trunk. The children then develop severe cachexia from the absorption of toxic products from the intestine, and die. They have all the symptoms of Group I. At autopsy these cases are found to have ulcerative processes of the mucous membrane of the large intestine and frequently submucous abscesses.

Group III.—After a history of constipation for a number of years the characteristic symptoms develop and the course of the disease is much the same as outlined above. To this class belong the so-called "balloon men" in whom the distention of the abdomen is so enormous as to make the lower part of the trunk almost globular.

Group IV.—These cases seem to be acquired late in life. They develop the full set of symptoms and the

physical signs which will be described below. A careful inquiry in the history will reveal that there has always been more or less trouble in securing voluntary evacuation of the bowel.

The general picture of the condition is very lucidly given by Hawkins as follows: "(1) A history of constipation from birth—compatible, however, with good health until the final stage, the first sign of failure being often loss of weight. (2) A constipation which often alternates with diarrhea and which at its worst is unlike that of obstruction, since flatus is often passed and fecal matter can be drained away through a rigid rectal tube. (3) Abdominal enlargement, variable or constant, often asymmetrical, with prominence in the left iliac region; the abdomen, though distended, is seldom tense and often surprisingly flaccid, and it rarely presents any impairment of resonance. (4) Slow alterations in shape, especially in the left iliac region, observable only with patience—unlike the tense peristalsis seen in real obstruction. (5) Absence or rarity of pain and vomiting."

The abdomen is often enormously distended. The lower colon and sigmoid may fill nearly the whole abdomen, displacing the liver upward and forming either a prominence resembling an extraordinary dilatation of the stomach or else looped upon itself so as to form two huge pipe-like prominences like a great inverted U extending vertically or obliquely up to the thorax. The dilated colon may measure two feet in circumference. When the dilatation is not of the sigmoid flexure it is usually near it. There are dyspeptic symptoms, especially colicky pains, and there is malnutrition. Frequently purgatives are effective; at other times they are of no value. It is characteristic that by inserting a firm catheter or drainage tube into the rectum, or even by passage of the finger, there will be secured a movement of the bowel and a discharge of gas. Roser says: "The introduced finger reveals a considerable narrowing; but above this is a large, sacciform distention." Göppert writes: "The finger passes through a normal rectum to a point six or seven centimeters above the anus, somewhat under the promontory (case, child of five weeks); on slight flexion the first phalanx of the inserted finger passes into a hollow space. If the finger is extended and withdrawn there occurs a passage of gas and feces and then with great ructus the abdomen collapses."

*Physical Signs.*—The distended abdomen is tympanitic throughout nearly its whole extent. The splenic dulness is obliterated, the hepatic dulness diminished, and the liver cannot be felt. The heart is displaced upward, and this gives rise to palpitation. There is dyspnea and there may be cyanosis, both of these symptoms being due to the pressure upward against the diaphragm. Usually neither coils of intestine nor peristaltic movements are visible. In very rare cases there is edema of the legs, scrotum, and penis, and also albuminuria, all of these symptoms being dependent upon pressure.

*Complications* are the results of pressure. There may be dyspnea, rarely hydronephrosis, and occasionally edema of the lower extremities. Tetany has been known to occur, and, as in the case of acute dilatation of the stomach, it requires immediate operation.

*Pathology.*—Necropsies have uniformly shown an enormous distention of the colon, varying from fifteen to thirty inches in circumference and extending from the upper part of the rectum a variable distance along the colon toward or to the cecum. There is always thickening of the muscular wall of the colon, which may reach a width of one-fourth of an inch. The bowel is thus rendered unusually rigid and shows little tendency to collapse or puncture. The mucous membrane is usually inflamed and at times studded with ulcerations. In a few cases submucous abscesses are present. The small intestine is never dilated. The distended bowel contains semifluid feces and a great deal of gas. Strictures have not been found. It is evident that the thickening of the muscular coat is a compensatory hypertrophy, and this hypertrophy affects both layers.

*Pathogenesis.*—The origin of the affection is not absolutely determined. Hirschsprung believed the condition to be a congenital primary dilatation and hypertrophy of the large intestine. Marfan regards it as secondary to a congenital anomaly in the form of the sigmoid flexure. Anatomical kinking has been advanced as explaining the condition. Roser and Perthes would lay stress upon the formation of a valve preventing the intestinal contents from passing down into the rectum; but the dilatation, as shown by Hawkins, begins gradually in the lower part of the pelvic colon, just above where it joins the rectum. The best explanation of the condition for all the groups of cases, advanced by Hawkins, is that it depends upon a congenital nervous defect in the lower part of the colon. The condition is almost always paralytic. One exceptional case of spastic contraction is that of Hilton Fagge (1880), reported by Gee. In this case there was a spastic condition below the immensely dilated pelvic colon; but the contraction was not very tight, easily admitting the index-finger.

*Diagnosis.*—The condition must be distinguished from intestinal obstruction, from tuberculous peritonitis, and from the simple non-dilating constipation. A careful comparison of the symptoms should prevent one mistaking the condition for intestinal obstruction. In its early stages there may be difficulty, however, in making the diagnosis from simple constipation and also, as Hawkins emphasizes, in recognizing the point at which the case becomes surgical. It is very important to make an early diagnosis, since there is a stage in some cases when cure is possible by surgical means. The *x*-ray picture taken after a bismuth and oil enema given in the knee-chest position may be of distinct aid.

*Prognosis.*—The prognosis is very bad, as nearly all the patients die if not operated upon. Many children suffering with this condition die early with obstinate constipation and extreme emaciation following repeated attacks of apparent intestinal occlusion. Other patients attain a greater age, but in these the symptoms have begun late. A few persons who were operated upon have recovered, and this really holds out the only hope after the condition has fully developed.

*Treatment.*—The treatment by medical measures has hitherto been unsatisfactory, and even the surgical treatment has not been very successful. Cathartics may be effective for a short time, but soon lose their power and add to the difficulties of the situation. Irrigation and the use of firm rectal tubes are the most effective measures. Faradization of the abdomen is an aid, but massage is dangerous, since, if the colon is ulcerated—as obtains in some cases—rupture may result.

Operative Measures.—Tapping the colon is dangerous and might easily lead to leakage and peritonitis, though the transverse colon was punctured in Cheadle's case and the patient recovered. An artificial anus was made in the cases of Osler and of Gwynne and the patients recovered. Parts of the colon have been excised successfully by Treves and Maurice Richardson. In the latter's case, however, although the sigmoid flexure was excised, a new hypertrophied sigmoid flexure was formed, large enough to fill the lower abdomen, in fifteen months. Resection of the affected portion with enteroanastomosis has given the best results. In Finney's case a preliminary colostomy was made in healthy bowel above the dilated segment; after the dilated portion had regained some of its bone, a lateral enteroanastomosis was made between the segments above and below the distended part. Later the whole of the affected portion was

excised and the free ends sutured. Finally the colostomy opening was closed. The operation by stages has great advantages as regards safety.

LINNÆUS E. LA FÉTRA

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**Colon, Surgery of the.**—Within recent years marked improvement has been made in the methods of examination of the colon, especially the sigmoid portion. The sigmoidoscope with direct illumination has made this portion of the gut quite easily visible to the naked eye. More recently Hanes[1] of Louisville, has devised a method of inversion of the trunk, employing a straight tube for examination of the sigmoid.

It is really remarkable with what ease and facility this instrument can be employed in this position and how satisfactory an inspection of the lumen of the gut can be readily obtained. By this method direct local applications can be made, specimens of tissue removed for examination, and small polypi enucleated. After the tube is introduced into the anus the obturator can be removed and under visual inspection the instrument gently passed into the bowel. The semilunar valves are readily passed and there is absolutely no danger of damaging the intestines. Those who have tried the method claim that it is the most practicable of all the means of inspection of this portion of the gut. With the patient in the inverted position and the tube *in situ*, large enemata can be administered without discomfort, and any form of medication may be applied to the colon. Dr. Hanes has also made some very important contributions to the study of the use of the ordinary colon tube. He claims, and has apparently proven, that tubes inserted into the intestine do not go higher than the beginning of the sigmoid, and that the angulation of the gut at this point prevents the tube passing into the descending colon. By numerous skiagrams and experiments

FIG. 1483.—Hanes' Table. Preliminary position.

on the dead subject, he has shown that a rubber tube may be carried as high as the umbilicus, and in extraordinary cases to the diaphragm, pushing the sigmoid along with it. The latter, of course, can be done only when the sigmoid is of unusual length.

WOUNDS.—The colon is wounded in the same manner as, though less frequently than, the small intestines. These wounds may occur from penetration of the abdomen by a knife, bullet, or blunt-pointed object, or rupture may occur from a contusion. Perforation from the effort to use the sigmoidoscope has also been reported. This is less likely to occur than formerly, especially if Hanes' position of the patient, which is mentioned above, is employed in making examination. Wounds of the colon often occur in the separation of adhesions during intraabdominal operations. The symptoms of a wound of the large intestine do not differ materially from those which present themselves when the small intestine is injured. Those

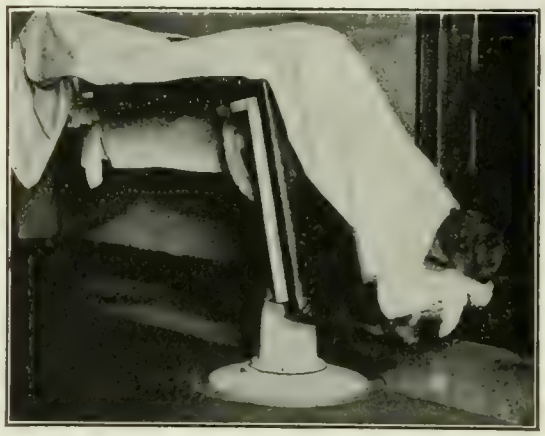

FIG. 1484.—Hanes' Table. Examining position.

wounds which are inflicted during operative procedures or in the course of an examination are readily observed. But accidental injuries can often only be surmised, the diagnosis of the part injured being determined only after an exploratory incision. While shock is to be expected in such wounds, it is frequently absent or present in only slight degree. Pain and tenderness are as a rule valuable symptoms, but their absence does not preclude the possibility of a wound. Paresis of the intestine and the resulting constipation usually occur early as the result of the violence producing the injury and later from the development of peritonitis. Vomiting is frequently an important symptom, especially as sepsis from extravasation develops. The presence of free gas in the peritoneal cavity is, if detected, a positive sign of rupture of the bowel. Tympanites over the area of normal liver dulness is a further evidence of this condition. Senn advised the rectal insufflation of hydrogen gas to determine the presence or absence of an intestinal wound, especially in connection with perforating gunshot wound of the abdomen; the diagnosis is made when the hydrogen escapes from the wound. When this test is successfully made, it proves positively the presence of a wound, but failure of the gas to escape does not exclude injury. This procedure is not devoid of danger, for the increase of intraintestinal pressure and the escape of the gas into the peritoneal cavity certainly favor fecal extravasation and seriously interfere with any operative procedure which may be necessary. This, coupled with the fact that only in from three to five per cent. of perforating wounds of the abdomen do the viscera escape injury, makes it more advisable to perform an exploratory operation, especially as the latter increases the mortality very slightly, if at all, when done with proper aseptic precautions.

The records of wounds of the colon show a larger percentage of recoveries without operation than do similar injuries of the small gut, owing perhaps to

the consistence of its contents and to less active peristalsis. These injuries are always serious and require prompt attention, as every hour of delay lessens the chance for recovery. Notwithstanding the number of reported recoveries without operation, the surgeon is certainly not justified in treating these cases expectantly. The method of dealing with intestinal wounds will be fully covered in another portion of this work. It is sufficient to state in this connection that the technique must be thorough and the closure perfect, sufficient lumen for the ready passage of feces being allowed.

Congenital Dilatation of the Colon, Giant Colon, Megacolon, or Hirschsprung's Disease.—This rare and interesting condition while casually mentioned by Parry in 1825 and Billiard in 1829, was first fully described by Hirschspung[2] in 1886. Since that time there have been many contributions to the subject. For a discussion of this condition see the article *Colon, Congenital Dilatation of the.*

Ptosis of the Colon.—Along with the increased activity on the part of the general profession in the study of Glenard's disease and visceral ptoses, much has been written concerning prolapse of the colon and many different plans have been proposed for the relief of the condition. We must admit that there are a limited number of cases of visceral ptosis in which operation is likely to prove beneficial, yet there is a far larger percentage which will not be relieved by operative interference no matter what method is employed. The question, therefore, of the advisability of operative interference in cases of visceral ptosis, and especially in ptosis of the colon, may be considered as yet undetermined. There is such a wide variation both in the length of the colon and in its relations to other abdominal viscera in different individuals that it is almost impossible for one to say just what is normal in a given case. What may be normal in one individual might under certain circumstances be abnormal in another. Again it is easy for the observer enthusiastically searching for certain conditions to mislead himself and find great abnormalities where others consider that the case is quite within the range of what is normal; one should, therefore, in studying these conditions not allow himself to be misled and attach too much importance to a considerable mobility of this structure. It is a well-known fact that the intestinal relations one with the other are by no means constant, but that as a general rule the cecum is placed in the right iliac fossa with the appendix lying in the same region, the latter showing a marked variation in the direction of its position in different individuals, the ascending colon being attached to the abdominal wall and covered by peritoneum on its front and sides. This condition holds until the hepatic flexure is reached, from which point the transverse colon extends across the abdomen as a sling or shelf, being very mobile and entirely surrounded by peritoneum. Its center normally lies slightly below the highest point of attachment of the colon on either the right or left side. At the left or splenic flexure the intestine descends along the abdominal wall and is again only partially covered with peritoneum until the brim of the pelvis is reached, at which point the close attachment to the wall gives place to a free mesenteric connection and a very mobile bowel, the sigmoid flexure. Very great difference in different cases is found in the length and mobility of this loop of the gut. In the opinion of the writer operation for fixation of the large intestine is permissible only in cases of wide variation from the above normal characteristics, and in the presence of distressing symptoms which can be explained only by these abnormalities. Recurrent attacks of partial volvulus, intussusception, repeated and marked intestinal toxemias, prolonged periods of constipation with great pain and distress when movement of the bowel occurs would be sufficient to justify interference.

The result of the fixation of an organ which is normally mobile is always doubtful and in many instances the condition of the patient is not improved, while in others the benefit is marked and the result very satisfactory. In considering the advisability of surgical operation upon a neurotic patient, as these usually are, one must weigh carefully the probable outcome of the case and must not overlook the fact that any operation will give a neurasthenic patient temporary relief from symptoms, but that no operation will entirely relieve their many and varied complaints. Space does not permit a comprehensive discussion of this subject, but the writer would urge the most careful study of the patient in this class of cases before operation is undertaken.

The administration of bismuth and the employment of skiagraphy with careful physical examination will enable the observer in the majority of cases to arrive at a proper conclusion. If rest in bed, general tonics, forced feeding, combined with laxatives and abdominal support, fail to benefit the patient, operation may be employed, one of the various forms of colopexy being indicated. In some of the more severe types, with very long loop and wide mesenteric attachment, resection will perhaps give the best results.

Adventitious Bands and Adhesions.—Sir Arbuthnot Lane[3] has called attention to a condition of angulation which occurs within the last few inches of the ileum as the result of adventitious bands of adhesion, binding that portion of the intestine to the posterior wall of the abdomen. He also mentions in this connection the sagging of the cecum as a factor in the angulation. These new bands of connective tissue extending from the intestinal wall to the parietes are in the majority of instances probably the results of some inflammatory condition, in many instances appendicitis. In rare cases, however, they may be congenital in formation. Jackson has mentioned a membrane which in some cases has united the ascending to the transverse colon with a very close attachment, and the name "Jackson's veil"[4] has been applied to this condition; also J. W. Long, of North Carolina, many years ago described a condition similar to this. Any form of inflammatory affection of the intestine is exceedingly likely to result in the formation of these fine web-like adhesions, which may occur in any part of the abdomen at which the inflammatory reaction may be excited. Here again it seems to the writer, as stated above concerning ptosis, that the surgeon should not be overzealous and find certain pathological lesions because he is looking for them and has been unable to find anything else to justify operation. There are so many adhesions formed at different portions of the abdomen which are seen by all who are familiar with abdominal surgery, that an extended description of them would be both unnecessary and unfruitful of results. Such conditions are to be met according to general surgical principles. The symptoms produced by any of these plastic deposits will be those resulting from interference with peristalsis and the normal function of the intestine, such as flatulence, eructation, distention, obstipation, toxemia with headache, malaise, varying very greatly in severity in different cases. These symptoms are quite similar to those found in connection with autointoxication and resulting from fecal stasis. Lane has attempted to attribute a wide variety of complaints to intestinal stasis and has advised the short circuiting of the bowel by implantation of the ileum into the cecum and also a complete excision of the colon for the relief of symptoms supposed to be due to fecal stasis. The writer believes that it is only in the most exceptional cases that an extensive operation, such as complete extirpation of the colon, is necessary. It seems likely that with

proper hygienic and dietetic treatment the very largest number of cases of constipation with incident of fecal stasis can be relieved by medicinal measures. When such measures fail one is very likely to find an organic interference in the passage of the intestinal contents, such as bands, kinks, internal hernia, strictures, tumors, etc., which, of course, demand surgical intervention. If there is any indication for Lane's operation it must be in those vary rare cases where the patients are known to go for weeks and even months without an evacuation of the bowels.

Ulceration.—Ulceration of the colon assumes surgical importance when a tendency to perforation or to the development of stricture results. Also in all chronic forms of ulceration, especially when due to the presence of *Amœba coli*. The causation and clinical history of many of these ulcerations are somewhat obscure. However, we meet with certain ulcers which present characteristics sufficiently distinct to be properly classified as dysenteric, typhoid, tuberculous, etc. The colon may be the seat of simple chronic ulcers similar in all respects to those seen in the stomach and duodenum. They occur very rarely, but are sometimes seen in patients suffering from Bright's disease. Vascular changes and emboli probably have much to do with their development. Sometimes a simple large ulcer is present, but as often several smaller ones are found. The edges of the ulcer are raised and slightly indurated, the base is somewhat regular. Healing may occur at one margin while the ulcerative process extends at the other. The ulcer may terminate by repair, and if, as is sometimes the case, it has extended around the intestine, narrowing may result. Perforation of the intestine is not infrequent and may be followed by fecal abscess and fistula or peritonitis and death.[5] Parker reports two cases that terminated in fecal abscess. Collections of feces retained for a long time in the intestine excite an increased secretion of mucus, produce softening of the epithelium and necrosis of the mucous membrane, and result in the formation of one or more stercoral ulcers. These ulcers may excite a localized plastic peritonitis or they may perforate and cause acute general inflammation of the peritoneum. The shock itself may prove fatal. The sudden onset of pain and prostration in a case of prolonged constipation, especially with the presence of a doughy, irregular, and variable tumor, will point to perforation from stercoral ulcer. Recently a most interesting illustration of the method of formation of stercoral ulcers came under my observation. A woman of fifty-six years was operated on for procidentia uteri, and the colon appeared to be the site of a number of small nodular tumors; the latter, upon examination, proved to be small fecal masses caught in diverticula extending into the appendices epiploicæ, which had small openings of communication leading to the lumen of the gut. It was only after careful examination that the exact condition could be determined. Ulceration at the seat of the solitary glands occurs in typhoid fever, and a few cases of perforation from such ulcers have been reported. These ulcers present the same changes which take place in the small intestine. Those ulcers which result from dysentery or which follow catarrhal colitis show little or no tendency to the formation of stricture. According to Woodward[6] no case of stenosis was reported as the result of chronic diarrhea or dysentery among the United States troops from 1861 to 1865, although a vast number of soldiers suffered from these diseases. Syphilitic ulcerations of the large intestine are usually limited to the rectum. They result from the breaking down of gummatous deposits in the submucous tissue. Malignant disease produces ulceration, and stenosis results from cicatricial contraction as well as from the encroachment of the neoplasm. Tuberculous ulceration occurs with great frequency. About one-half of the cases of tuberculosis show lesions in the intestine. The lung is the only organ more often attacked. These lesions are situated most often at the lower part of the ileum and in the beginning of the colon. They may be primary, or secondary to a focus situated elsewhere. In children primary involvement is the rule and the intestinal lesion may be so slight as to escape notice, while the mesenteric glands will be greatly involved. In adults the lesions are more often secondary, and the solitary glands of the cecum are often involved and show the characteristic deposit of tubercle. This deposit undergoes softening and the cheesy material is emptied into the intestine. An ulcer results which tends to spread around the circumference of the intestine, in the course of the vessels, as well as deeply through the wall. The peritoneum over the ulcer often shows yellowish, opaque tubercles in its structure, the surrounding tissues become adherent, and contraction of the inflammatory product may cause constriction of the intestine. The girdling ulcers tend in their repair to produce stenosis and frequently excite symptoms of obstruction. Perforation of the intestine is by no means infrequent and may give rise to fecal abscess and subsequent fistula or may excite general peritonitis as in simple ulcer. Ulceration of the colon presents few characteristic symptoms; there may, in fact, be nothing to indicate the condition even when marked and extensive lesions are present. Diarrhea, more or less persistent, with periodical constipation is usually present. Mucus, shreds of tissue, some blood and pus may at times be found in the discharges. In tuberculous ulceration, the patient will lose in flesh and strength and will complain of pain, especially in the lower part of the abdomen. This pain is increased upon slight exertion. Localized tenderness on pressure without rigidity may be noted in these cases, and, as in other tuberculous processes, a slight evening elevation of temperature may be observed. As stricture develops, after the symptoms named above have lasted for months, constipation becomes more and more marked until the stools are completely arrested. In rare cases this condition may occur suddenly and may present the usual symptoms of intestinal obstruction, as nausea, vomiting, pain, distention, and obstinate constipation. Perforation will be known by the shock, distention, pain, tympanites, etc.

*Diagnosis.*—The diagnosis is at times difficult, and in many cases the presence of ulcers can be determined only after stenosis occurs. This is especially true in the proximal portions of the large intestine. Under present methods of examination and the use of the sigmoidoscope, however, the detection of ulcers in the lower part of the large bowel (sigmoid and rectum) has become somewhat easy. In ulceration due to *Amœba coli*, parasites are more certainly obtained for observation by curetting away some tissue from the base and margins of one or more of the ulcers than is possible from an examination of the dejecta. The organisms are exceedingly likely to be overlooked in the usual method of examining the feces.

*Treatment.*—The treatment of ulceration in the colon has been very much improved in recent years, this being especially true of the amebic or dysenteric type. If upon examination the diagnosis of the latter condition is made, the intestine should be thoroughly flushed with physiological saline solution for cleansing purposes. This is followed by injections of tannic acid, a heaping teaspoonful to the quart of water. In the course of one or two hours this again is followed by an injection of a solution of the fluid extract of ipecac, one dram to a quart of sterile water. This injection may be given in a reclining posture or in the knee-chest or inverted position, the latter being employed in cases where the irritability of the bowel is very great and causes too rapid expulsion in the other position. In some cases in which the bowel is very irritable in-

jections of coal-oil will be found most gratifying and prove beneficial. Rest is undoubtedly of value in the treatment of this condition and careful attention to the diet is necessary, but the patient should not be restricted too severely as to either the quantity or the quality of his food. The patient should take liberal quantities of rich nourishing foods, with the exception of vegetables, fruits, and sweets. In the acute stage of the process the diet perhaps will have to be restricted more closely to farinaceous material and milk.

Ipecacuanha is much employed in the internal treatment of this disease and given in this way is usually accompanied by some preparation of opium to prevent too vigorous action of the drug. Various forms of intestinal antiseptics and astringents have been administered but with uncertain results. Recently some observers have claimed to get marvelous results from the internal use of emetine.

In cases in which the above plan of treatment fails the operation of appendicostomy and colostomy[7,8] also that of cecostomy have been proposed to aid in obtaining a cure. Through the opening made by either of these methods thorough colon lavage can be employed and any of the remedies mentioned above can be placed directly in contact with the ulcerated mucosa. These operations will only be necessary in the most intractable cases of this disease.

Tuberculous and malignant cases may not be diagnosticated until stenosis causes intestinal obstruction, thus adding very greatly to the gravity of the condition. In such cases where a complete resection of the diseased part is possible this should be done. If the patient's condition will not permit of this procedure then much benefit can be obtained by a colostomy made on the proximal portion of the gut.

Stenosis.—Non-malignant stenosis may follow almost any form of ulceration, but the most frequent process is one of a tuberculous nature. The constriction may take place a long time after the ulceration. Owing to this fact strictures are noted more frequently in adults than in children. Many cases of stenosis are unrecognized during the life of the patient. Two or more points of stricture may be present in the same case. No portion of the colon is exempt from this lesion.

*Symptoms.*—The chief symptom of stenosis is constipation, which may gradually become more and more persistent or may occur suddenly and become complete. If relieved temporarily, a return of the constipation is to be expected in a short time. The patient will perhaps give a history of troublesome diarrhea, the passage of some mucus and blood having occurred at some previous time. Obstructive symptoms sooner or later set in, and, while not so marked as in some other forms of obstruction, are very persistent. Uneasiness in the abdomen soon becomes pain which is paroxysmal and is increased by purgatives. The abdomen may become distended, but as a rule it is flaccid unless peritonitis is present. After a time vomiting begins, first of gastric contents, later of feces unless the obstruction is relieved. The patient loses flesh and strength and, after some days of suffering, death follows from sepsis and exhaustion.

*Diagnosis.*—The symptoms of recurring and more or less obstinate constipation, when associated with emaciation and in the absence of stenosis of the rectum, will usually mean stricture of the colon. Obstruction of the small intestine will usually present a more acute train of symptoms. In stenosis of the colon vomiting is not so prominent a symptom and becomes fecal at a much later date than it does in occlusion of the small gut. The absence of a neoplasm will exclude malignant stenosis although it is difficult to exclude small annular carcinomatous growths. The use of the skiagraph has proven of great service in detecting both benign and malignant constrictions, it is to be employed after the ingestion of bismuth subnitrate.

*Treatment.*—Avoidance of purgatives will save the patient much discomfort. Copious enemata will give relief during the early stages. When obstruction occurs or attacks of constipation are often repeated, operation is indicated.

Fecal Fistula.—Sinuses leading from the colon to the surface and discharging feces and gas result from wounds which have not been treated or which have been improperly closed; from contusions without immediate rupture but followed by sloughing; and, finally, from slipping of the ligature or sloughing of the stump after operative interference for the relief of appendicitis. The pressure of a drainage tube is not infrequently a cause of this condition. The same is true of gauze drainage, the removal of which sometimes produces a tear of the intestine. Tuberculosis of the colon may cause perforation and thus lead to the formation of fecal fistula. In dealing with strangulated hernia associated with gangrene of the gut, the surgeon may deem it best, if the patient's condition precludes the completion of colectomy, to temporize by the establishment of a fecal fistula to be cured by a subsequent operation (colotomy). In malignant disease the formation of a permanent fistula (artificial anus, colostomy) has become a recognized surgical procedure.

*Pathology.*—When from any cause the continuity of the intestinal wall is disturbed, gas and feces in a short time escape, and under the most favorable conditions excite a localized plastic inflammation in the surrounding peritoneal surfaces, with the tendency to the formation of adhesions and isolation of the focus of irritation. In time the surface is reached through an abscess—where the abdominal wall is intact—or through the wound if one exists, and the feces then escape externally. When a wound of the abdomen is present, the communication is usually established within a week after the injury. When the abdominal wall is intact, a longer time will elapse before the fistula develops. The general peritoneum is protected by a fibrinous lymph, and the fistula is lined with granulation tissue. When the damage to the colon is slight and when surrounding parts lie in close relation to the wound of the gut, the tract will gradually contract and eventually heal. This is the most frequent termination of such cases. A fistula may persist when the intestine is fixed directly to the skin without intervening sinus, when the wound in the bowel is very large, or when more than one opening exists; also when there is obstruction to the passage of feces through the bowel below the fistula, owing to a stricture, tumor, or bend of the intestine. Tuberculous fistulæ are very persistent, and repair will be unlikely when an abscess cavity is formed in close proximity to the intestinal opening, due perhaps to a failure of the walls of the abscess to collapse. The symptoms indicating the development of fecal fistula are the presence of a peculiar dark, blackish brown stain upon the dressings and the detection of a distinct and persistent fecal odor. A mistake is scarcely possible. Some difficulty may be experienced in determining the location of the intestinal opening, but this will prove of little moment. In some instances progressive emaciation accompanies the condition, but usually the patient is well nourished. The prognosis of this condition is as a rule good, and special attention will be demanded only after it persists for some months. The affection is always disagreeable, but its seriousness is certainly less than in the case of a fistula leading to the small intestine.

*Treatment.*—Upon first impulse it would appear reasonable to effect drainage in some form to remove the feces and to keep the skin wound patulous. Considerable experience in such cases teaches us that such a procedure is unnecessary and frequently productive

of harm, owing to the fact that no drain will carry off the feces as well as the pressure within the intestine. Moreover, when the fecal matter remains pent up in the tract, symptoms of sepsis shortly appear. The condition is best treated by placing over the external opening a large loose pad of sterilized absorbent material, and retaining it in place by a bandage. These dressings should be changed whenever they become soiled; sometimes this is necessary as often as four or five times a day. When the dressings are changed, gentle pressure near the fistula will force out the contents and cleanse the tract. The skin should be washed with cold water and alcohol, and when any excoriation occurs the parts should be anointed with zinc ointment or vaseline at each dressing. The bowel below the fistula should be kept patulous by enemata to make the passage easier in that direction than through the abnormal tract. Laxatives should be used only to prevent constipation and too great solidity of excreta.

The patient's health should be kept up by tonics and nutritious easily digestible food. If, after several months of this treatment, the fistula persists or if emaciation is rapid, an operation for the cure of the affection should be undertaken. This operation is often very difficult, but, with proper care to protect the general peritoneum, it can usually be safely accomplished. Cleansing of the field of operation must be absolute. The tract should be well scraped and thoroughly flushed with 1 to 1,000 bichloride solution. In curetting the fistula care must be exercised to avoid injury of an adjacent fold of intestine. The application of pure carbolic acid to the tract is advisable, and this should immediately be followed by the application of about eighty-per-cent. alcohol to prevent too extensive action. In order that the canal may easily be traced it should be packed with gauze. The incision should be made with the greatest care to avoid injury of the bowel, which is almost always adherent to the abdominal wall around the fistula. Therefore begin the cut some distance away from the fistula, and after the peritoneum is opened, with the finger inside the abdomen, separate the adhesions until the incision can be safely continued. Protect the general peritoneum with flat gauze sponges. When the tract is short the intestine can be readily loosened, lifted into the wound, and sutured or resected. When the bowel lies six or eight inches from the outlet of the fistula, considerable dissection will be necessary to free the adhesions and this requires the greatest care. The edges of intestinal openings are pared if necessary and coapted by Lembert sutures of fine silk. Usually a second supplementary series of sutures will be necessary. When the intestinal wound is so large that the lumen of the gut will be constricted, a colectomy will be necessary. The toilet of the peritoneum must be made in the most thorough fashion, and after the tract of the fistula in the abdominal wall has been excised, the wound may be closed completely—provided the operator is convinced that the peritoneum has not been soiled—or it may be left sufficiently open to provide the necessary drainage outlet. The old method of closing an artificial anus by the pressure of a clamp, as advised by Dupuytren in 1815, certainly has no advantages over the operation just described and is not to be recommended.

Intussusception; Invagination.—The abnormal reception of a portion of the intestine within an adjoining and continuous segment constitutes an intussusception. This condition may develop in any part of the canal, but is most likely to occur at the ileocecal valve. It forms about forty per cent. of all fatal cases of intestinal obstruction. According to Treves, fifty per cent. of such cases occur under two years of age. At the point of invagination three thicknesses of the intestinal wall lie in close proximity to each other. The outside fold is known as the receiving layer or intussuscipiens, the internal as the entering layer, and the middle is called the returning layer. The last two are also known as the intussusceptum. The peritoneal coverings of the entering (internal) and the returning (middle) layers lie in contact and in a short time become firmly united, while the mucous surfaces of the receiving and returning folds show no such tendency.

The descent of the gut exerts traction upon the mesentery and compression of its vessels at the point of invagination, thus producing venous obstruction with swelling and edema of the intussusceptum. Softening and gangrene may produce perforation, or bacteria may multiply rapidly in the congested wall and excite a speedily fatal form of peritonitis. In rare cases nature effects a cure through sloughing of the invaginated segment, after adhesions have formed, at the line of entrance, sufficiently strong to prevent rupture. Usually intussusception is acute and rapidly fatal, but in adults one may encounter the chronic form which after two or three weeks of suffering may terminate in recovery, or which may prove fatal through chronic diarrhea, septic emboli, perforation, peritonitis, etc. As a rule, in children it is quickly fatal. Its causation is not well understood. Spasmodic peristalsis, which forces the contracted portion into a relaxed segment, or a paralyzed segment into a normal one, has been advanced to account for its development. The experiments of Nothnagel seem to show that contraction of the longitudinal muscular fibers will draw a relaxed portion over a contracted one. The presence of polypi is supposed to favor the development of invagination. The anatomical relation of the ileum to the cecum must also be considered as a predisposing factor,

*Symptoms.*—The attack begins suddenly with severe griping and colicky pains, accompanied by marked anxiety and shock. Vomiting is usually present, as is constipation after the bowel below the obstruction is emptied of its contents. Some mucus and blood may pass and the tenesmus is marked. Upon examination a sausage-like abdominal tumor can often be detected, especially when the end of the ileum has entered the colon.

The *diagnosis* is based upon the sudden onset, peculiar pain, sausage-shaped tumor, and the passage of blood-stained mucus without feces. At times the exact cause of the obstruction will be determined only after the abdomen is opened. The prognosis, as incidentally mentioned before, is always grave, and in most cases a fatal termination occurs in less than one week.

*Treatment.*—Avoid purgatives, and during the first twenty-four hours endeavor to set free the invaginated segment by distension of the colon with gas, air, or water, while the patient is in the knee-chest position. Belladona and opium may be cautiously administered to allay spasm and limit peristalsis. Do not give enough opium to mask the symptoms. If this treatment fails to relieve, a laparotomy should be performed—preferably the median operation, unless a well defined tumor is present, in which case the incision should be made directly over the swelling. Stimulants will frequently be needed to counteract shock.

*Technique.*—Under the strictest asepsis the abdomen is opened and search made for the seat of obstruction, first in the right iliac fossa and with as little exposure of the intestines as is practicable. A needless exposure of the intestines will greatly increase shock and lessen the chances of recovery. The mass should be brought into the wound and protected by hot pads of gauze, while gentle efforts are made to relieve the invagination. If continuity is restored without damage to the bowel, recurrence can be prevented by suturing the mesentery to the abdominal wall. If reduction is impossible, if malignant disease is present, or if the intestine is gangrenous, colectomy should at once be performed, and

resort to colostomy should be had only when the patient's condition prevents the operator from making the complete operation. The wall of the abdomen is to be closed as in other cases of abdominal section.

Volvulus.—Volvulus constitutes one of the most fatal forms of intestinal obstruction. The term is applied to a twisting of a segment of the intestine and its mesentery so that the circulation of the blood and also the passage of feces are interrupted. Such a twist can occur only in cases in which the peritoneal attachment is sufficiently long to allow considerable mobility of the gut. The sigmoid flexure, therefore, is the part of the colon which is most subject to this accident. Sudden distention of the intestine with gas, or the presence of a fecal mass, with or without an accompanying strain, may cause volvulus. When the torsion occurs, swelling of the twisted portion follows immediately, owing to interference with the return of venous blood. This swelling tends to accentuate the twist and to increase the obstruction to the blood supply. The adjacent portions of the intestine are distended with gas, which tends to prevent spontaneous restoration. Gangrene follows in a short time, and peritionitis is present if the patient lives long enough for its development. The prognosis is essentially grave. Spontaneous restoration rarely, if ever, occurs and no measures save operation offer any hope to the patient.

*Symptoms.*—The patient is suddenly seized with vomiting, which is not so severe in volvulus of the colon as it is in volvulus of the ileum. Severe paroxysmal pain radiating over the abdomen, with extreme tenderness, is always present. Sudden cessation of pain announces the development of gangrene. Pain returns with the development of peritonitis. Obstruction is complete. Early and circumscribed tympanites may precede general distention and rigidity. Rectal examination may reveal a mass in the pelvis in case a twist lies in that region. Marked restlessness and prostration are always present and the patient shows great anxiety. The surface shortly becomes cold and clammy and covered with perspiration. Hiccough soon appears and the circulatory and muscular system become rapidly depressed.

*Diagnosis.*—Sudden onset of obstinate constipation (bowels regular before), vomiting, pain, tenderness, and localized tympanites without a tumor or a hernia will point strongly to volvulus. It is not always possible to make out the exact seat of the obstruction, but the symptoms described will call for exploration.

*Treatment.*—Palliative measures, purgatives, rectal injections, etc., are worse than useless. An early laparotomy offers the only hope for the sufferer. When this is performed early the result is very gratifying, but delay is dangerous. The mesentery should be sutured to the abdominal wall to prevent recurrence. When the bowel is gangrenous (which is shown by its dark color and the ease with which the peritoneum is separated from the muscularis), immediate resection with end-to-end or lateral anastomosis, or the formation of a fecal fistula, is the proper surgical procedure to be adopted.

Impaction.—Fecal impactions are more likely to occur in the colon than in the small intestine, but less frequently perhaps than in the rectum. The right and left iliac fossæ are the most frequent sites. This condition develops in patients who have a tendency to constipation and the accumulation occurs more or less slowly with intermittent attacks of diarrhea until ulceration or complete obstruction occurs.

*Symptoms.*—Sometimes the first symptoms are diarrhea with tenesmus, night sweats, loss of appetite, flesh, and strength, following a more or less constipated condition. In time constipation will take the place of the diarrhea and there will be evidence of obstruction associated with pain, slight tenderness, and distention. Examination will reveal a tumor which is doughy to the feel, which can be indented, and which varies in size and shape.

*Treatment.*—Large enemata of salines, oil, soapsuds, etc., in Hegar's knee-chest position, with gentle kneading of the abdomen, will usually afford relief. If these means fail, the surgeon should resort to a laparotomy, which will render it possible to break up the mass by gentle manipulation of the intestine. Recurrence can be prevented by the administration of such remedies as belladonna, nux vomica, aloes, and cascara sagrada to tone up the intestine. Daily massage of the abdomen and proper diet are of marked benefit. When the mass is very large and danger of rupture of an ulcerated colon is present, a colotomy is justifiable.

Tumors.—Benign tumors rarely develop in the colon. Papillomata, adenomata, and fibromata sometimes form pedunculated tumors that project into the intestine and thus may give rise to intussusception by exciting efforts of expulsion. They may also grow to sufficient size to produce obstruction. As a rule these growths are single, but occasionally they are multiple. Lipomata sometimes appear as pedunculated growths upon the peritoneal surface of the intestine, where they have as a rule little pathological importance. These tumors also develop in the submucous tissue, extend into the intestine, and may even completely occlude the canal. Hofmokl[9] reports a case of this kind in which the tumor obstructed the lumen of the intestine for a distance of several inches and caused invagination of the colon. Annular benign growths are sometimes seen springing from the middle coat of the intestine; these are, as a rule, fibromyomata. Benign growths only demand attention when they cause intussusception or obstruction.

*Sarcoma* attacks the colon very rarely indeed, even less frequently than it does the small intestine. Sarcomatous growths springing from adjacent organs may involve the colon and in the course of their growth produce obstruction. Clinically it is impossible to differentiate between sarcoma and carcinoma of this structure. Sarcoma possesses no tendency to spread through the lymphatics and may be expected to occur earlier in life than carcinoma. The final results are very similar in either instance. Owing to the amount of involvement which takes place before these tumors are recognized, removal rarely proves of benefit and an early recurrence is to be expected. Therefore enterocolostomy, or as it is sometimes called, short-circuiting of the intestine, will be the operation that offers the most to these patients. By this procedure the irritation of the feces and the tendency to obstruction can be relieved. Senn has proven that a segment of intestine isolated in this way is able to rid itself of its secretions and of feces which may enter it accidentally.

*Carcinoma.*—The large intestine is somewhat frequently attacked by this variety of neoplasm; about seven per cent. of all cancers have their origin in this organ. According to Sutton, ninety-eight out of every one hundred intestinal cancers have their origin in the large bowel and about seventy-five of these involve the rectum, ten the sigmoid flexure, and thirteen the cecum and remainder of the colon. According to Leube, four-fifths of all cancers of the large intestine occur in the rectum and one-fifth in the colon and sigmoid. These growths spring from the mucous surface and from the glands of that structure and infiltrate, as they grow, into the deeper tissues of the intestinal wall. The histological structure resembles more or less closely that of the benign adenomata, yet this variety of new growth shows a great tendency to infiltrate surrounding tissue. These tumors may project into the lumen of the intestine or spread through the submucous tissue until the entire circumference of the bowel is involved. In

time ulceration occurs, and with it the contraction of the newly formed tissue until the canal is partially or completely occluded. Secondary involvement of the intestine by extension from carcinomata of neighboring organs not infrequently occurs, and as a rule such cases are inoperable owing to the wide dissemination of the disease. Cancer of the large intestine may exist for some time without giving rise to any distinct symptoms indicative of its presence. During this time some irregularity of the bowels may be present, but as a rule not of sufficient moment to demand attention. After a time there may be noted a sense of uneasiness or discomfort in the abdomen, and this is soon followed by more or less constant pain and tenderness. This pain is at times colicky in character. Loss of flesh and strength greatly out of proportion to the discomfort of the patient accompanies the foregoing symptoms. The appetite and digestion are at first unimpaired, but cachexia soon develops. When ulceration begins, blood-stained mucus, shreds of broken-down tissue, and some pus are passed with the feces. As the ulceration progresses diarrhea and pain become constant and severe, and the slight septic intoxication which results causes loss of appetite and anemia. Constipation becomes more and more marked until complete obstruction develops as the result of stricture. Intestinal obstruction may be the first symptom to appear. Ulceration often

Fig. 1485.—Illustrating a Malignant Stricture at the Junction of the Sigmoid and Rectum. (Hanes' case.)

occurs above the stricture, and a number of fistulæ may form between the two portions of the intestine or between the proximal portion and the surface. The surrounding parts become involved finally and a peritonitis with ascites develops. Examination at this time will reveal the presence of a nodular tumor unless it is masked by the ascites.

*Diagnosis.*—The diagnosis of carcinoma of the colon can be made by careful consideration of the symptoms mentioned above. Rapid emaciation, and the history of irregularity of the bowels, uneasiness and pain in the abdomen, with a gradually increasing costiveness will point strongly to cancer of the intestine. A very important sign of the development of obstruction from malignant disease is to be found in a marked peristalsis in which movement of the intestine can be readily seen through the abdominal wall. In some cases this is a very prominent symptom. The writer would urge close attention to the development of these symptoms in the early course of the disease, since the only hope offered these patients is to be found when operation is done before the disease has advanced to very great extent. The microscopic examination of the feces for occult blood and the employment of the *x*-ray as previously mentioned, will be found very useful aids in arriving at a diagnosis. Some cases will perhaps be cleared up only at operation, but if the attendant delays until a palpable tumor is observed, the patient's chance for recovery will be greatly diminished.

*Prognosis.*—This is, as a rule, a fatal affection. The only chance offered for the patient is by an early and complete extirpation of the disease. In cases in which this is impossible and in which symptoms of obstruction or marked ulceration are present, either colostomy or lateral anastomosis will give temporary relief and perhaps extend the life of the patient. Colostomy is to be performed when an inoperable growth is situated in the lower portion of the intestine. Lateral anastomosis is indicated when the growth is situated high in the colon and extirpation is not feasible.

Colopexy.—This operation is employed for the relief of marked displacement of the colon from its normal position. The site of the abdominal incision should be made to correspond with the portion of the gut which is displaced; the median incision will prove satisfactory for most cases, since in cases of ptosis the mesenteric attachments are usually quite long and the gut easily accessible. A number of different plans of fixation have been proposed by different writers on this subject. In localized ptosis fixation to the abdominal wall will be very easily accomplished, but where the whole colon is displaced great care must be exercised in placing the sutures so that no angulation of the intestine results. The sigmoid flexure, which is most likely to be the part affected, has a natural curve like the trap of a water-closet and has a function quite similar to that. It is therefore necessary in cases which demand interference to bear this conformation in mind and to place the sutures of fixation so that this will be to some extent retained. These sutures can be placed between the peritoneum of the intestine and the parietes, or can extend through into the fascia of the abdominal wall. Gant has proposed that the sigmoid be lifted and the rectus muscle carried through its mesentery, thus providing a sling which would hold it up in place. The latter method necessitates the intestine being carried out of the abdominal cavity and held within the layers of the abdominal wall, which would seem to render the development of angulation quite likely.

Colotomy.—This term has for centuries been used to designate the formation of an artificial anus, but recent writers have limited its meaning to incision of the colon for the purpose of making a temporary opening; while the term colostomy is applied to the establishment, by operative measures, of a permanent opening into the colon. Therefore we shall in this connection make a distinction in accordance with the literal meaning of the terms. Colotomy is indicated for the removal of foreign bodies lodged in this part of the intestine, for the relief of fecal impactions which cannot be otherwise removed, for the establishment of a temporary opening in a case of imperforate anus, or in one of ulceration of the rectum or lower part of the colon. The incision should be made over the swelling in the first two instances, or in the median line if the diagnosis is not made. When the operation is made for imperforate anus, the left inguinal region is best, as it also is for colostomy. When the intestine, which may be recognized by the longitudinal bands and fatty appendages, has been pulled into

the wound, the diagnosis should be confirmed before proceeding with the operation. The peritoneum should be protected by gauze and an incision made longitudinally through the wall of the intestine. The foreign body or fecal concretion should then be extracted and the part thoroughly flushed with saline solution. Closure of the intestinal wound is then accomplished by interrupted Lembert sutures of fine silk or of strong catgut. The needle should penetrate the submucosa which holds the stitch in place. It will usually be advisable to supplement with a second row of sutures. When one is satisfied that approximation is perfect, the colon should again be flushed and dropped into the abdominal cavity. The abdominal wall is closed in the usual manner without drainage. When the operation is performed for imperforate anus and for painful ulceration and inflammation of the rectum, the intestine should be brought only partially out of the wound and fixed with angulation so that excision will not be necessary when a cure of the fistula is indicated.

Colostomy.—Artificial Anus or Colostomy is the operation of forming a more or less permanent opening from the colon to the surface. The indications for colostomy are:

1. Obstruction of the intestine below, (*a*) from inoperable tumor; (*b*) from stricture of the rectum or colon.
2. Congenital malformation of the rectum and anus.
3. To relieve the pain and irritation of intractable ulceration of the rectum, either simple, syphilitic, tuberculous, or cancerous, and to prevent the feces passing over the diseased area.
4. To relieve incurable rectovesical fistula.

*Iliac colostomy* was first proposed by Littré in 1710 and frequently is known as Littré's operation, although it was not performed until 1776 by Pillore. It was employed at intervals after this time, but with a mortality so high that it was abandoned in favor of lumbar colostomy, proposed by Callisen in 1796 and successfully performed by Amussat in 1839. According to the statistics of Dr. Batt, the mortality of the lumbar method was thirty-one per cent. and of the iliac fifty-three per cent. Mr. Cripps performed fourteen lumbar and twenty-seven inguinal colostomies with one death. With the perfection of surgical technique, the objections to the inguinal method have disappeared, so that at the present time lumbar colostomy is rarely performed. Inguinal colostomy places the artificial anus in a position where the patient can properly care for it with ease. The colon is more readily accessible by this route than through the loin, and the operation is equally safe. The fecal flow can scarcely be entirely cut off from the lower part of the intestine in the lumbar operation, thus failing to meet an important indication, and when a long mesocolon is present the lumbar route is useless. Objections have been urged to the establishment of a fecal fistula in any case, but patients can pass a very comfortable existence for a number of years after its formation. Those patients are most comfortable who have means and leisure to take care of themselves, but even the working class can follow their usual vocations with comparative comfort. When the stricture or growth is situated in the lower sigmoid or rectum and is of such extent that excision cannot be safely accomplished, a colostomy in the inguinal region is the operation of choice. When the obstruction lies higher in the colon, the opening can be made in the transverse portion or in the cecum, but the usual site is in the left iliac fossa. An incision about three inches in length should be made parallel to Poupart's ligament and about one inch and a half internal to the anterior superior spine of the ilium. This incision at its middle should cross an imaginary line drawn from the anterior superior spine to the umbilicus. If each layer of muscular fibers is separated by blunt dissection and the retractor used to keep the wound open, considerable control over the orifice can be obtained for the patient after repair has occurred. The finger introduced into the wound and carried deeply outward toward the anterior spine will catch and bring the colon into the wound where it can readily be recognized. The intestine should be pulled down until the mesocolon is on the stretch to prevent prolapse through the artificial opening. The whole thickness of the gut should be brought out of the wound to make a strong flexure, and it should be held there by a glass rod through the mesocolon as advised by Maydl, or by a silkworm-gut suture as advised by Kelsey, or simply by the suture to the peritoneum.

The skin, the peritoneum of the parietes, and the wall of the intestine should be united by eight or ten sutures of catgut or silk, thus closing the peritoneal cavity from chance of infection when the intestine is opened. Before these sutures are inserted, one or two silkworm-gut stitches should be passed through skin, muscles, and fascia at the upper and lower angles of the incision to bring the tissues snugly about the bowel. The wound can be hermetically sealed by a thin layer of sterilized cotton and collodion, leaving the intestine exposed for immediate opening if desired. When the wall of the intestine is pared away some hemorrhage may require attention. In cases in which the symptoms of obstruction are not urgent it is quite proper to wait three or four days before incising the intestine, as the mortality heretofore has been greatly decreased by such delay. General anesthesia is usually unnecessary for opening the intestine after such postponement.

*Lumbar Colostomy.*—This operation, much in vogue formerly, often known as Amussat's operation, can be more readily performed if the colon is distended, as in stricture with obstruction. Under anesthesia the patient should be placed on his right side upon a firm pillow to arch the left loin as much as possible. A perpendicular line drawn from the middle of the crest of the ilium, or, according to Allingham, from a point a half inch behind the middle, will mark the situation of the colon. An incision four inches long should be made parallel to the last rib and half way between it and the crest of the ilium with its center in the line just mentioned. The muscular tissue and fascia for the whole length of the wound must be carefully divided intil the transversalis fascia and the edge of the quadratus lumborum are exposed. When this fascia is cut through, the colon will present itself. Unless it is collapsed it can easily be recognized by its color, by the thickness of its walls, and by the scybalous masses which it usually contains. Care should be exercised to avoid opening the peritoneum. The colon should be drawn into the wound and sutured to each margin. The wound should be closed with silkworm gut, an opening being left at one point for drainage; and when obstructive symptoms are not urgent several days may elapse before the intestine is opened.

Colectomy.—Excision of part of the colon has been performed with considerable frequency during the past ten years. The ileocecal coil appears from the reported cases to be the part most often removed (ileocolectomy). Magill in 1894[10] collected one hundred and four cases of resection of this portion of the bowel, with a mortality of thirty per cent. The first resection of the ileocecal fold was performed by Krausshold, 1879, with a fatal result. Maydl, in 1882, operated successfully. Since that time the operation has become a recognized surgical procedure. The following conditions may demand resection of the colon: 1, malignant disease (carcinoma and sarcoma); 2, tuberculosis; 3, invagination, acute and chronic; 4, fecal fistula; 5, gangrene from volvulus or bands; 6, gangrene from hernia; 7, wounds with con-

siderable loss of substance; 8, inflammatory strictures; 9, irreducible cecum in hernia;[11] 10, Hirschsprung's disease; 11, certain cases of ptosis.

The feasibility of resection can be determined only after exploration and inspection of the diseased intestine. The most frequent indication for the operation will be a removable malignant growth; the other conditions mentioned are also frequently best treated by colectomy. The large number of fatalities formerly occurring after this operation appeared to be due to faulty technique, and improvement along this line has materially lessened the death rate. In a recent report Mayo shows in 61 resections for malignant disease, 8 deaths (13 per cent.); and for benign diseases of the large intestine 39 cases with 4 deaths (10 per cent.); of 16 cases operated upon more than three years ago, whose histories have been followed, 9 are alive and well today.

The preparation of the patient should be the same as that carried out for any abdominal operation and should receive the most careful attention. In cases of obstruction purgatives cannot be used, but in other instances the canal should be thoroughly emptied of its contents and for forty-eight hours before operation the intestines should remain quiet (Hochenegg). Two very cogent reasons have been offered for this preliminary purgation, one is that the number of bacteria is greatly lessened, and the other is that a semi-solid intestinal content can be taken care of at operation much better than if it were fluid. In this connection it may be well to urge that preliminary gastric lavage in all cases of intestinal obstruction is of the greatest value.

The incision in the operation of colectomy should be made at a point which will give free access to the diseased bowel, and if the diagnosis of the site of the obstruction is not certain the median incision should be employed. When the site of the obstruction is known, the incision should be made internally to it and should be sufficiently long to expose readily the diseased portion. The next step, which is very important, consists in mobilization of the attached portion of the gut. This can be accomplished by incising the external lamella of the peritoneum as it passes from the intestine to the parietes of the abdomen. This can be safely done because the inner layer carries most of the blood supply. After mobilization is accomplished the vessels can be seen and easily ligated in the inner portion of the mesentery. All bleeding from the wound should be arrested before the peritoneum is opened. The diseased portion of the intestine should be well isolated by gauze pads to prevent contamination of the peritoneal cavity, the greatest care being employed to prevent soiling of the field by the intestinal contents throughout the operation. The mesentery of the segment to be removed should be tied off in sections or clamped and ligatured after the bowel is removed. The first is perhaps the better method. These ligatures should be of strong catgut and the included mesentery should

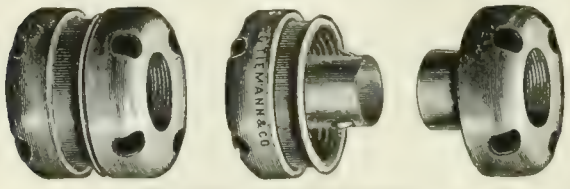


Fig 1486.—Murphy's Buttons.

not extend beyond the point at which the intestine is to be divided. In the presence of acute obstruction the operation of colectomy is very much more dangerous than when such condition does not exist. The explanation for this fact lies in the intense toxemia which develops from the rapid growth of the bacterial flora in the intestine, therefore the bowel above and below the portion to be removed is emptied as nearly as possible of its contents and held firmly closed by the fingers of an assistant, by rubber-covered clamps, or by gauze tapes. The intestine is then divided by sharp scissors and dissected carefully away from the surrounding parts. Watch must be kept for the ureter, which may be wounded in resection of either end of the colon. The continuity of the intestine can then be restored (1) by end-to-end sutures, (2) by direct suture or lateral anastomosis, (3) by lateral or end-to-end anastomosis with the aid of Murphy's buttons, (4) by lateral implantation in ileocolectomy.

In cases in which the patient's condition will not permit the completion of any of these steps a fecal fistula can be formed. It should be remembered, however, that this entails the danger of a later operation and therefore should be avoided if possible. The end-to-end suture may be accomplished by the method of Czerny-Lembert (modified by Woelffler), which calls for two rows of sutures, the first penetrating the mucous and muscular coats, but not the serous. The peritoneum is inverted by the second row of sutures inserted after the method of Lembert. The following method is more often employed: The cut ends of the intestine are held together by an assistant while interrupted Lembert sutures are inserted at intervals around the bowel to approximate the segments. These sutures should invert less than one-eighth of an inch of the open wall of the intestine, thus bringing the serous surfaces into apposition. Another row of Lembert sutures, interrupted or continued, should be applied over the approximation sutures to render the closure efficient. The greatest difficulty in preventing leakage will be experienced at the mesenteric border; therefore especial care must be given to suturing at that point. Too great inversion of the cut edges may produce obstruction when repair is accomplished. The operator should be perfectly sure that the walls of the intestine are impervious and that its lumen has been restored before he completes the other steps of the operation. This can be determined by forcing the contents from above through the point of anastomosis, while the intestine is occluded below by pressure of the hand. The exposed parts should be thoroughly flushed, the redundant mesentery folded and sutured in such a manner that it cannot possibly produce strangulation, and the intestine dropped into the abdomen. When the suturing is perfect there need be no fear of extravasation, and gauze wicks are therefore unnecessary and often productive of harm. The omentum is drawn down in front of the intestines and the abdomen closed without any provision being made for drainage. It has been claimed that anastomosis by suturing, either end-to-end or laterally, requires considerably more time than when absorbable plates or buttons are employed, that leakage is more likely, and therefore that it is not as useful as one of the latter methods. The same amount of preparation for this operation in the dead-house or upon animals will make an operator about equally expert in the use of either plan. Leakage is no more likely from direct suturing than when some appliance is used, and perhaps less so, owing to the sloughing which sometimes follows the use of either the button or the absorbable plate. The Murphy button undoubtedly affords the most rapid method for anastomosis, and in the colon will cause little inconvenience from its presence as a foreign body. The different forms of clamps proposed for anastomosis require more skill in manipulation than the other methods, save nothing in time, and will scarcely be generally adopted. The Murphy button is the best of the mechanical aids to intestinal suturing, and is equally suitable for end-to-end or lateral anastomosis. One section of the button is held in the open intestine by a running stitch, known as a purse-string suture, which is pulled tightly around the button as it is tied.

The sections of the button are then pushed together and locked. The mesentery should be cared for as in the direct suture and the operation completed in the same way.

Lateral Implantation is the method of suturing the cut end of the small bowel into an incision in the colon. The incision in the colon is made longitudinally and is not quite so long as the diameter of the ileum. The end of the ileum is fastened into the side of the colon by two rows of sutures, the first approximating the mucosa; the second suture brings the serous surfaces together thus reinforcing the first line of suture. The end of the colon is closed by interrupted Lembert sutures.

After excision of the intestine the patient should have no solid food for about four days. The diet should consist of liquid easily assimilable food. On the third day a laxative can be administered, and, after the bowels move, feeding can be commenced.

J. Garland Sherrill.

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**Colony Treatment of Epileptics and the Insane.**—The use of a colony system in the treatment of epilepsies and psychoses dates from remote times. The general underlying principle has been to follow as closely as possible the natural developments in society and to afford a community life for these individuals shut out from the enjoyment of freedom in an active community. From this broadly humanistic standpoint other features of more or less enduring value have been evolved. Thus there have come about colonies for the alcoholic, farm colonies for the indigent, colonies or villages for the feeble-minded, and the aged and infirm. Specialization, whereby specific modes of handling closely related problems is made possible, has given rise to all these later developments only a brief outline of which is possible here.

It would be natural that all individuals with antisocial tendencies would be the first to be segregated from society and kept away. In ancient times there thus resulted jails and almshouses. Here all the classes mentioned found a habitation under—at times—most appalling conditions.

It was not from such nuclei that the earliest colonies for treatment sprang up—the general prison attitude of mankind, which seeks to punish rather than to uplift, does not look in the right direction. The earliest of modern colonies—we must omit consideration of the ancient Greek and Roman health resorts, patterned after earlier models, and even later Roman health colonies—is probably that at Gheel in Belgium. Here, in the fifth and sixth centuries, about a religious shrine, similar to earlier shrines consideration of which must be omitted, there began to grow up a community life devoted to the cure of individuals with mental disorders. From these early beginnings there has grown up a colony hospital scheme, which has been very successful under the conditions found in Belgium. Here those patients who can be cared for in simple homes are thus looked after; they live the life of the peasant. Those more actively sick are taken care of in special infirmaries. The whole colony is managed as a hospital community, and is admirable in every respect. In the sixteenth century history tells us 400 patients were cared for. When Esquirol visited Gheel in 1821 the numbers varied from 400 to 600. It was not until 1850, however, that organization entered to regulate what had been more or less a haphazard development. The State then took over control from the local authorities. From that time to the present there has been gradual development, so that now the whole problem is handled as an up-to-date hospital problem, the individual beds, etc., being as it were distributed over the country. A corps of physicians is constantly making visits. With this as a model many similar institutions have been attempted. St. Anne, near Paris, was started in 1832 as an industrial colony for the insane. It became a closed asylum. The colony FitzJames, near Clermont, started in 1861 and went through a somewhat similar evolution, but there have been colony formations along the lines here noted in almost all European countries, some of which still prosper, while others have been neglected or have developed into other types of institutions.

Similar movements have been begun in the United States, but it cannot be said that they have prospered, *i.e.* those more familial in their character following the Gheel plan. The Village or Cottage Institution plan, which is really a cottage type of institution, has been much more satisfactory from the standpoint of organization. It is doubtful if a familial—*i.e.* housing out—scheme will work altogether satisfactorily save in more permanent communities. Certain New England villages have tentatively been utilized. The experiments are still in progress and it remains to be seen how they may work out. There is little doubt that for certain individuals such a method of dealing with them is to be preferred to the somewhat cut and dried ways of the average institution, where individualization has little opportunity and collectivism is a hindrance to all personal effort. It takes a lot of effort to adjust the patients who may possibly be able to live out, and few have the patience and ability to establish the proper adaptation. In many European countries there is a more stable and uniform peasant class. Here the needy widow and spinster must take the place of the European peasant. The economies of the plan have been preeminently satisfactory in Belgium. The cost of maintenance has been less under the familial system than the institution plan, and the benefit to the caretaker has been direct and not roundabout. More caretakers are provided for, but the general standard of living, in Gheel for example, is extremely simple.

Cottage villages, or institutions that are built on a village plan, are also termed colonies. Here the general scheme is quite different from the boarding out or true colonization plan. Such schemes are purely matters of architecture and plumbing with a reduction in the size of the individual groups, with a nearer approach to familial conditions. They are preferable from nearly every point of view to the large single building types of construction for certain kinds of patients. For others the economy of the mass has advantages for the tax payer, and is productive of no harm to the patient. (See Letchworth, "The Insane in Foreign Countries and At Home.")

The village or colony, *i.e.* cottage plan, is admirably adapted for the care of the indigent epileptic. As this general group shows antisocial tendencies in but comparatively small percentages their segregation from the population followed many years later than the separation of the psychotic. The historical treatment may be found in Letchworth's "Treatment and Care of the Epileptic." The earliest of the successful colonies was that of Bielefeld, where family groupings were attempted. This was begun about 1867, and from twenty-four patients the Bielefeld Colony, a purely private philanthropic enterprise

has grown to be a village of 3,000 individuals, epileptics and their carers. It is a model in many ways.

In the United States the Ohio Colony was among the first. Craig Colony in New York, the work chiefly of Mr. Letchworth and its first superintendent Dr. W. P. Spratling, is a model institution where nearly 2,000 epileptics are taken care of and treated. New Jersey, Pennsylvania, Massachusetts, and other States now segregate many of their epileptics in much the same manner. The Transactions of the American Society for the Study of Epilepsy and the International periodical *Epilepsia* contain a large number of papers to which the interested reader may turn to obtain numberless details which cannot be considered here. The colony or cottage system plan is admirably adapted to the care and treatment of the epileptic, and institutions such as Craig Colony are a great saving to the community rather than an expense.

Many of the institutions contribute very materially to their own support, excellent scientific work is done, a practical eugenic result is obtained by segregation, thereby limiting epileptic descendants. Such developments are now located in nearly all European and English speaking countries. They are making headway in some South American States as well.

SMITH ELY JELLIFFE.

**Colophony.**—See *Turpentine*.

**Color Perception.**—The part of the eye which is chiefly concerned in the perception of light and color is the retina, an outcrop of the brain, to which it is connected by the optic nerve. The retina is a delicate transparent membrane lining the back of the eye-ball and when examined under the microscope is seen to be a very complex structure made up of ten layers. The sensitive nerve elements are on the posterior surface of the retina next the choroid and rays of light have to pass through the thickness of the retina before giving rise to visual impulses. The sensitive elements of the retina are called from their shape, rods and cones. The rods consist of basal enlarged portions with slender rod-like processes which dip into the pigment layer. In the outer parts of the rods is diffused the "visual purple," a substance highly sensitive to light. The cones are conical or pear-shaped bodies one-half the length of the rods, with much shorter processes, containing no visual purple. Each cone communicates through the intervening retinal neuron with a single neuron of the optic nerve. Between the rods and the cones and the choroid coat is a layer of pigment cells which send processes in among the rods, and seem to have something to do with forming the visual purple. The rods and cones are not equally distributed over the retina. The fovea, where vision is most distinct, contains only cones; at the borders of this region each cone is surrounded by a ring of rods; the number of rings of rods round each cone increases as the periphery is approached and at the margin only rods are found.

*The Visual Purple.*—The pigment epithelium, which is so intimately connected with the delicate endings of the rods and cones, may be regarded as a glandular organ which secretes the visual purple. Ball discovered that the visual purple was, in the living animal, susceptible to light. He found that when the eye of a frog, which had been kept for some time in the dark, was rapidly opened, the outer limbs of the rods of the retina presented a very beautiful purple or rose color, which, after a few seconds, changed into a yellow and finally disappeared, leaving the rods colorless. If the frog had previously been exposed for some time to a bright light, the retina, even with the most rapid manipulation, was found to be colorless, and by examining at intervals the eyes of a series of frogs, which, after being kept in the dark, had been exposed to light for variable periods it was found that the color of the rods was destroyed by exposure to light and restored by rest in the dark. It has also been found that pigment cells, under the influence of light, wander between the rods and cones—a phenomenon which is not observed in the dark. The pigment cells, however, never retire completely from the rods, but constantly inclose the outer third. The time necessary for the ascent and descent of the pigment cells is exactly the same as that observed in the appearance and disappearance of the visual purple.

*Distribution of Color Sense over the Retina.*—The boundaries of visual sensations in the retina can be determined by means of an instrument called a *perimeter*. The subject sits in front of the instrument with his back toward the light and having covered one eye, rests his chin on the support and fixes the uncovered eye on a white dot placed at the center of the perimeter. The test-object, a small square of white or colored paper, is then moved slowly along the inner surface of the arc, from the periphery toward the center and the subject reports the instant the color is recognized. This point having been noted on a specially prepared chart the other radii are tested in like manner. By this means the field of vision for white and colors is mapped out. A study of such a field shows that the field for white and black extends to the periphery; the fields for blue and yellow are about ten degrees smaller, while the fields for red and green are smallest of all and occupy only the central half of the entire field. It would seem, therefore, that we are totally color-blind in the peripheral portion of the visual field, red-green blind in a middle zone, and have a perfect chromatic sense only over a small central area.

*Function of the Rods and Cones.*—From the peculiar distribution of the rods and cones in the retina and from a study of the field for white and colors it would seem that the function of the rods is in some way related to the reception of light stimuli of feeble intensity; and that the function of the cones is concerned with distinctness of vision and with the perception of color.

COLOR VISION.—If a ray of solar light be made to pass through a prism it is decomposed into a band of colored rays, which is known as the solar spectrum (Fig. 1487). Although the spectrum is made up of an infinite number of tints, we distinguish seven principal colors—*i.e.* red, orange, yellow, green, blue, indigo,

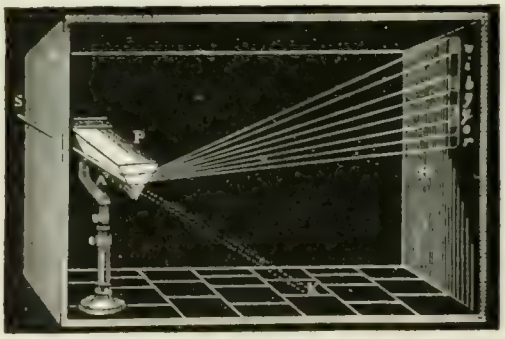


FIG. 1487.—The Splitting of a Ray of Solar Light, Passing through a Prism, into the Spectrum. (Ganot.)

and violet. The colors of the spectrum are the result of motion in the ether, in the form of undulations or waves, and each color is due to a series of these waves of a definite length. The elongated shape of the spectrum is due to the fact that the violet rays are most refrangible, that is, have the smallest wave-lengths, and are most deflected toward the base of the prism. At the other end of the spectrum are the red rays, which are least refrangible, have the greatest wave-lengths, and are least deflected. At the two ends of

the spectrum are other rays not perceptible unless the rest of the spectrum is shut off. At the violet end are the ultra violet or actinic rays of a grayish-blue tint. At the red end are the infra red or heat rays which probably make no impression on the retina because they are absorbed. The spectral rays are

Fig. 1488.—Deflection of the Violet Rays in Passing through a Second Prism, without further Decomposition. (Ganot.)

saturated or simple colors; that is, they cannot be further decomposed by a prism. If all of the rays of the spectrum, except the violet, be intercepted by means of the screen E (Fig. 1488) and if the violet rays be made to pass through a second prism B, refraction takes place, but the light received on the screen H remains unchanged.

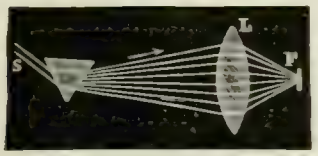


Fig. 1489.—Recomposition of the Spectrum into White Light when Passed through a Double Convex Lens. (Ganot.)

*Recomposition of White Light.*—White light which has been decomposed by a prism into the various colors of the spectrum may be reproduced by combining the colored rays. If the spectrum be allowed to fall upon a double-convex lens (Fig. 1489) the rays are reunited to form a pencil of white light on the screen F, placed at the focus of the lens.

That white light can be produced from a combination of the spectral colors can be demonstrated by means of Newton's disc. This consists of a cardboard

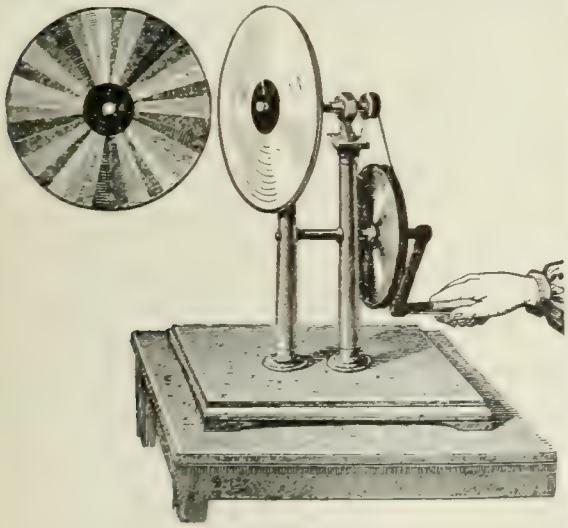

Fig. 1490.—Newton's Disc.

disc about one foot in diameter, upon which is pasted strips of colored paper to represent five spectra; the center is covered with black paper (Fig. 1490). When the disc is rapidly rotated the retina receives the impression of white (gray).

*Mixed Colors.*—In nature we find a large number of colors, tints, and hues which do not appear among the spectral colors. Colors such as purple, gray, and brown are mixtures of one or more spectral colors with white and black. Thus, a mixture of red and blue in certain proportions gives rise to the sensation of purple; a small amount of white mixed with black results in the sensation of gray, and brown is formed from a mixture of red, yellow, white, and black.

The qualities of a color depend upon tint, saturation, and intensity. *Tint* is that property of color which is due to a definite refrangibility or wave-length of the constituent rays. *Saturation* depends upon the greater or lesser admixture of white light with the colors of the spectrum; the more white in the mixture, the less saturated will be the color. *Intensity* depends on the amplitude of vibration—*i.e.* the amount of colored light which falls on the same area of the retina in a given time. Mixed colors may be produced by causing two or more colors of the spectrum to fall on the same part of the retina in rapid succession. The color-sensation resulting from this fusion is not the same as is made by a mixture of pigments of the same colors. Thus, a mixture of yellow and indigo of the spectrum gives rise to a sensation of white, while a mixture of yellow and indigo pigments appears green.

*Complementary Colors.*—Those colors which, when mixed together in pairs give rise to a sensation of white, are termed complementary colors. These colors are: red and bluish-green, orange and blue, green and violet. A peculiarity of complementary colors is that they never can be perceived at the same time in the same color. A red color may be seen to have some blue or yellow mixed with it, but we can never say of a color that it is a mixture of red and green. Red, green, and violet, the most widely separated colors in the spectrum, when combined in certain proportions will produce white. Hence all possible colors may be constructed of red, green, and violet and for that reason they are called primary colors.

*After-images and Contrasts.*—After-images are visual sensations which remain after the withdrawal of the stimulus and may be positive or negative. If one looks at a bright light for several seconds and then shuts his eyes, he perceives a positive after-image of the light; it is *positive* because it is the same color as the light. A *negative* after-image is always of its complementary color; if one gazes fixedly for some time at a piece of red paper and then turns his eyes to a white surface, a greenish blue after-image is seen instead of a red one.

*Contrasts.*—A color appears to be of a deeper hue when placed side by side with its complementary color; green appears greener when near red, and blue bluer when near yellow. These color effects are called contrasts.

*Color of Bodies.*—The color of a body depends upon its power to absorb certain portions of white or other mixed lights, and to reflect or transmit other portions. The resulting color-effect is the impression made upon the retina by the unabsorbed rays. If the unabsorbed rays are transmitted the body is colored and transparent; if, on the contrary, the rays are reflected, it is colored and opaque. Those which reflect or transmit all colors in the proportion in which they exist in the spectrum are white; those which reflect or transmit none are black. The various tints in nature are dependent upon the greater or lesser extent to which bodies reflect or transmit some colors and absorb others. Hence bodies have no color of their own; the color changes with the nature of the incident light. To a person wearing dark green spectacles all red objects appear black, because the red rays are absorbed by the green glasses and there are no rays remaining to affect the eye. The color of the costumes of actors may be changed at will by flooding them with a light of the desired tint.

*Edridge-Green's Color Perception Spectrometer.*—This instrumant (see Fig. 1491) is a spectrometer so arranged as to make it possible to expose to view in the eyepiece the portion of a spectrum between any two desired wave-lengths. It consists of the usual parts of a prism spectroscope, *i.e.* a collimator with adjustable slit, prism, and telescope with an eyepiece.

In the focal plane of the telescope are two adjustable shutters with vertical edges; the shutters being carried by levers which rotate about centers near the object-glass of the telescope. The shutters can be moved

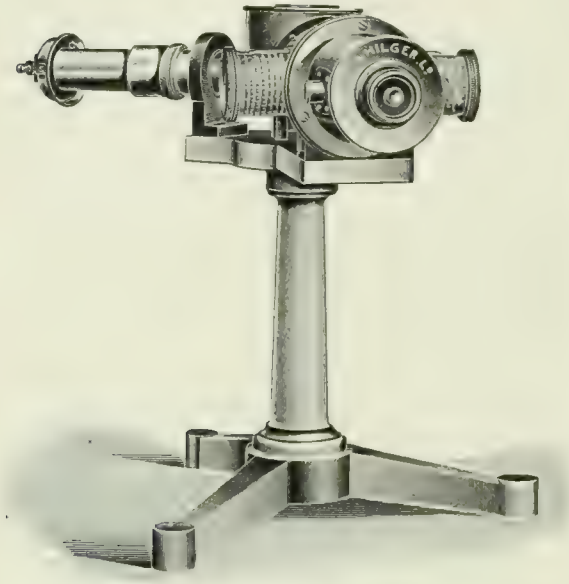

Fig. 1491.—Edridge-Green Perception Spectrometer.

into the field from right and left respectively, each by its own micrometer screw, and to each screw is attached a drum, the one being on the right and the other on the left of the telescope. On each of these drums is cut a helical slot in which runs an index, and the drum is engraved (see Fig. 1493) in such a manner that the reading of the index gives the position in the spectrum of the corresponding shutter in wave-lengths direct.

Thus it will be seen that if, for instance, the reading on the left drumhead is 5320 and that on the right

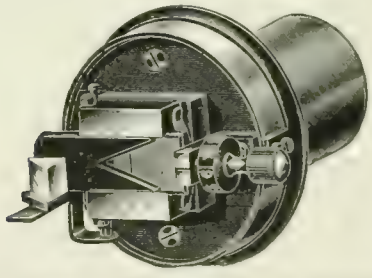

Fig. 1492.—Adjustable Screw and Prism in the Edridge-Green Spectrometer.

drumhead is 5920, the region of the spectrum from wave-length 5320 to wave-length 5920 is exposed to view in the eyepiece.

The instrument is used as follows: The instrument should be used as far as possible with a known quality and intensity of light. A small oil-lamp is quite suitable for the purpose. The observer should first ascertain the exact position of the termination of the red end of the spectrum, the left-hand shutter being moved across until every trace of red just disappears. The position of the pointer on the left-hand drum is noted, and the wave-length recorded. The left drum is then moved so that the shutter is more toward the middle of the spectrum The right-hand drum is then moved until the pointer indicates the wave-length recorded as the termination of the red end of the spectrum. The observer then moves the left-hand shutter in and out until he obtains the largest portion of red, which appears absolutely monochromatic to him, no notice being taken of variations in brightness, but only in hue. The position of the index on the left-hand drum is recorded. The left-hand shutter is then moved more toward the violet end of

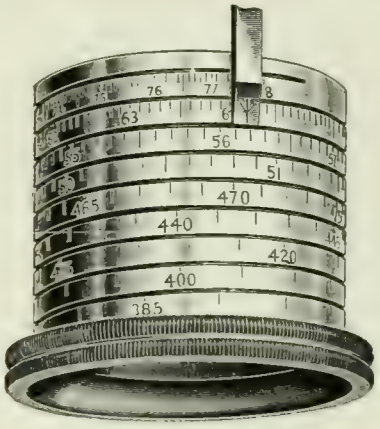


Fig. 1493.—One of the Drums in the Edridge-Green Perception Spectrometer.

the spectrum, the right hand shutter being placed at the position previously occupied by the left-hand shutter. In this way the whole of the spectrum is traversed until the termination of the violet end of the spectrum is fully ascertained with the right-hand shutter. The variations of the size of the patches and the terminations of the spectrum with different intensities of light can be noted. The instrument can also be used for ascertaining the exact position and size of the neutral patch in dichromics, the position of greatest luminosity, and the size and extent of pure colors. When it is used to test color-blindness, the examined should first be shown some portion of the interior of the spectrum, and then asked to name the various colors which he sees. In this way he will have no clue to the colors which are being shown him. (This instrument is made by Adam Hilger, Ltd., 75a Camden Road, London, N.W.)

Color-blindness is a total or partial lack of development of the color-sense. Total color-blindness, in which all objects appear white, black, or some shade of gray, is very rare. Partial color-blindness is a defect for one of the primary colors, red, green, or violet (Helmholtz); or the blindness may be for red and green or blue and yellow, according to Hering. Red-green blindness is the common form of the defect; it is usually congenital and is found in about four per cent. of males and in about one-fourth of one per cent. of females. It is thought that its rarity among women may be accounted for by the fact that from time immemorial their color sense has been trained by work which required a constant handling and comparison of colors.

Theories of Color-perception.—Various theories have been advanced to account for the phenomena of color-perception and color-blindness. Each has its adherents, but it cannot be said that any one of them satisfactorily explains all the known facts. The most noted theory and the one probably having the

greatest number of adherents is the Young-Helmholtz. This theory is the basis of Holmgren's widely used worsted test for color blindness.

*The Young-Helmholtz Theory.*—The original theory of Thomas Young (1807) supposes the retina to contain three sets of color-perceiving cones, corresponding to the three primary colors, red, green, and violet, and regards all other colors as varying mixtures of these. Helmholtz (1850) modified this hypothesis by suggesting that every kind of light excites the red, green, and violet perceiving cones at the same time but with different degrees of intensity. In Fig. 1494, A

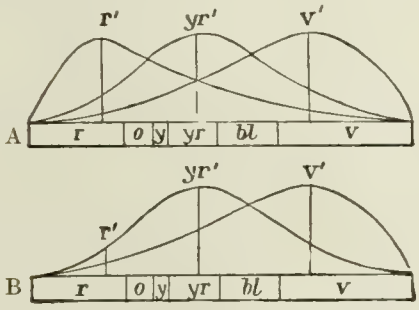


Fig. 1494.—Diagram Illustrating the Young-Helmholtz Theory of Color-perception. (After Fuchs.)

the three curves represent the excitability of the red, green and violet perceiving cones to solar light; the colors of the spectrum are placed along the horizontal line, beginning with red (r) and ending with violet (v). The pure red of the spectrum strongly excites the red perceiving cones, to a less degree the green, and still less the violet. Under these circumstances we get a sensation of red, because the degree of excitation of the cones for the perception of red exceeds that of the other cones. Orange light strongly excites the cones sensitive to red and to a less degree the green. Pure yellow light strongly excites the cones sensitive to red and green, but very feebly those sensitive to violet. From this almost equal mixture of red and green arises the sensation of yellow. Green light strongly excites the cones sensitive to green, but to a much lesser degree, the cones sensitive to red and violet. Pure blue light strongly excites the cones sensitive to green and violet and but feebly the cones sensitive to red. Violet light strongly excites the violet-perceiving cones, more feebly those for the perception of green and least of all those for the perception of red; hence the sensation of violet.

In red-blindness the cones for the perception of red are absent. To a man blind to red the spectrum appears shortened at its red end since he sees only blackness where the normal eye still perceives red. Spectral red feebly excites the green perceiving cones and scarcely at all the violet, so that the resultant effect will be a green of feeble intensity (bluish green). (Fig. 1494, B.) Spectral green strongly excites the green perceiving cones, less so the violet and again the effect produced is green, but of a more pronounced shade. To a red blind individual therefore both red and green appear green and the only way in which he can distinguish these two sensations from each other is by their difference in luminosity; the red seems a darker green than the real green. The white of the red blind is a combination of their two primary colors—green and violet—a combination which appears blue-gray to the normal eye; this is why they regard as gray the spectral transition colors from green to blue. The *green-blind* has for his primary colors, red and violet. Spectral red, which strongly excites the red perceiving cones and but very faintly the violet, appears to the green-blind as an extremely saturated red. Green, with its shades inclining to yellow and blue, ought to be a saturated purple, but it is the white (gray) of the green-blind, because it is composed of almost equal parts of their primary colors, red and violet. The *violet-blind* has for his primary colors red and green and these colors appear strongly luminous but less saturated, more whitish than normal. Some of the objections to this theory are as follows: It presupposes a specialization of nerve fiber; it does not explain the fact that the periphery of the retina is color-blind, or that black is a true sensation; it does not explain the phenomena of contrasts, and accounts poorly for the negative after-images seen with closed eyes.

*The Hering Theory.*—This theory is based upon an analysis of color sensations, all but four pure colors—red, green, blue, and yellow—excites in us a mixed sensation. Thus, some shades of green give us an impression of a mixture of green and yellow, others of a mixture of red and blue, and orange or red and yellow. Still, among the various shades of color, we are able to pick out a certain tint of red and blue, green and yellow, which excite in us a simple unmixed sensation. They are called primary colors, and form two pairs, namely, red and green, and yellow and blue. The two colors of each pair stand in an antagonistic relation to each other and exclude each other. In other words, if the two colors of a pair fall upon the same portion of the retina at the same time, the resulting sensation is of that color which is in excess, but never of both together. If they are mixed in certain proportions so that they neutralize each other, the resulting sensation is white (gray); hence they are called complementary colors. The existence of these mutually exclusive colors would seem to show two opposing processes going on in the retina, one a process of chemical breaking down, or disassimilation, the other a process of building up, or assimilation. According to this theory, white and colored light produce chemical changes in the visual substances which are assumed to be present in the retina. The visual substances are of three kinds—a white-black substance, a red-green substance, and a blue-yellow substance. White light falling on the retina breaks down the white-black substance and gives rise to the sensation of white. In the absence of white light this substance is building up and we have the sensation of blackness. The red-green and the blue-yellow substances are not altered by every kind of light, but only by light of corresponding color value. Pure red light would break down the red-green substance and give the sensation of red, while green light would cause assimilation and give the sensation of green.

According to the Hering theory, color-blindness is due to the absence of one or of both of the visual substances for colors. If both are absent there is total color-blindness, and all colors reacting only on the white-black substance appear as white of different degrees of luminosity (*i.e.* gray). Blue-yellow blindness, denoting an absence of the blue-yellow visual substance, is rarely observed. Red-green blindness in which the red-green visual substance is wanting, is quite common and corresponds to the red-blind and the green-blind of Helmholtz. To the red-green blind red and green appear white (gray) and the only colors seen in the spectrum are yellow and blue, between which is a neutral gray space corresponding to the green. This theory gives a satisfactory explanation of the distribution of color vision in the retina, of negative after-images and contrasts, but its assumption of specific nerve energies resulting from opposing chemical processes is not supported by similar activities in other parts of the body.

*The Franklin Theory.*—From the peculiar distribution of color-vision over the retina Franklin suggests that the more complex color-perceptions are evolved from simpler ones.

The primary photochemical substance is a gray-

perceiving substance found in all the rods and in the cones of the periphery. This gray-perceiving substance is dissociated in the cones of the blue-yellow field into blue-perceiving and yellow-perceiving substances. The central cones contain a red-, a green-, and a blue-perceiving substance, the red and the green being due to a still further decomposition of the yellow. Since all are derived from the gray-perceiving substance their combined stimulation produces a sensation of gray. Color-blindness is due to failure of dissociation of the yellow-perceiving substance.

The most important contributor of recent years to the subject of color-vision and color-blindness is F. W. Edridge-Green, M.D., of London. His theory of color-vision explains the fundamental facts of color perception more satisfactorily than any other theory so far advanced. We have his kind permission to quote freely from his writings.

*The Edridge-Green Theory.*—A ray of light impinging on the retina liberates the visual purple from the rods and a photograph is formed. The rods are concerned only with the formation and distribution of the visual purple not with the conveyance of light impulses to the brain. The decomposition of the visual purple by light chemically stimulates the ends of the cones (very probably through the electricity which is produced), and a visual impulse is set up which is conveyed through the optic nerve fibers to the brain. The character of the impulse set up differs according to the wave-length of light causing it. Therefore, in the impulse itself we have the physiological basis of the sensation of light, and in the quality of the impulse the physiological basis of the sensation of color. The impulse, being conveyed along the optic nerve to the brain, stimulates the visual center, causing a sensation of light, and passing on to the color-perceiving center, causes a sensation of color. But though the impulses vary in character according to the wave-length of the light causing them, the color-perceiving center is not able to discriminate between the character of adjacent impulses, the nerve cells not being sufficiently developed for the purpose. At most, seven distinct colors are seen, while others see in proportion to the development of their color-perceiving centers, only six, five, four, three, two, or one. This causes color-blindness—the person seeing only two or three colors instead of the normal six, putting colors together as alike which are seen by the normal-sighted to be different.

According to this theory the visual purple is the visual substance and is the essential factor in both vision and color perception. It accounts for many facts which were previously inexplicable. For instance, a bright light may fall upon the fovea (the center of the yellow spot) without producing any sensation, and a perceptible interval elapses before we are able to see with the yellow spot, after the remainder of the retina, the fovea being the last point to convey a sensation of light. The first fact we should expect, the cones being insensitive to light; the second corresponds to the diffusion into the yellow spot of the visual purple. All the facts of color mixing, contrast, and after-images can be explained by the hypothesis that the visual purple is the visual substance.

Cases of color-blindness may be divided into two classes, which are quite separate and distinct from each other, though both may be present in the same person. In the first class there is light as well as color loss. In the second class the perception of light is the same as in the normal sighted, but there is a defect in the perception of color. In the first class certain rays are perceived either not at all or very imperfectly. Both these classes are represented by analogous conditions in the perception of sounds. The first class of the color-blind is represented by those who are unable to hear very high or very low notes. The second class of the color-blind is represented by those who possess what is commonly called a defective musical ear. Color-blind individuals belonging to this class can be arranged in a series. At one end of this series are the normal sighted, and at the other the totally color-blind. The colors appear at the points of greatest difference. Edridge-Green classifies the color-blind in accordance with the number of colors which are seen in the spectrum. If the normal sighted people be designated hexachromic, those who see five colors may be called pentachromic; those who see four, tetrachromic; those who see three, trichromic; those who see two, dichromic; and the totally color-blind, monochromic. There are many degrees included in the dichromic class. There may or may not be a neutral band, and this is widest in those cases approaching most nearly to total color-blindness.

J. Ellis Jennings.

**Color Perception, Tests for, in Railway and Marine Service.**—In order better to understand the various tests for color blindness it is deemed wise to describe first the signals in railway and marine service in which the recognition of color is demanded.

Signals.—Three distinct forms of signals are necessary in railway operations—"All clear; proceed;" "Caution; proceed slowly;" and "Danger; stop;" and by night this information must be given by means of color. In marine service in order to give information as to the course of a vessel at night colored lights are a necessary adjunct. Thus it will be understood why it is so essential that those in control of trains in railway service and those in charge of vessels or on lookout duty in marine service should have perfect color perception.

Railway signals requiring recognition of color are divided into two grand classes, fixed and moving. It is quite generally accepted that red designates danger, green or yellow caution, and white or green clear. Blue is used as a caution signal to indicate repairs being made.

The day fixed signals in which the color must be recognized are flags, switch targets, train order signals, interlocking block signals, and drawbridge signals.

*Flags.*—These are displayed at stations or are placed along the track by trackmen to indicate danger, or caution to regulate speed of trains over a section of track in poor condition, etc. They are also displayed on the pilots of engines as classification signals and on the rear of trains as markers. They are made of bunting about sixteen inches by eighteen inches, and are red, white, green, and blue when new.

*Switch Targets.*—These are used to designate the condition of the switches in relation to the main track or side tracks, and are of three general divisions, high, medium, and low depending upon the height above the road-bed. They indicate the position of the switch—diverting rails by the shape, position and color of the target, which may be square, oval, round, kidney-shaped, an arrow, a bar or feather, etc. The colors used are red, green, white, yellow, black, or any combination of these colors, according to the judgment of the officers of the various roads.

*Train-order Signals.*—These are used to stop a train to receive orders. They commonly are sheet iron discs of various shapes, attached to station buildings and under control of the station master. The newer forms are semaphore arms attached to the buildings or on a mast isolated from the building. The colors used in the old form are red, green, white, and black, or a combination of the same.

*Interlocking Signals.*—These are usually of the semaphore type, and are located alongside the track on the right-hand side and adjacent to, where possible, or on bridges immediately over the track they govern. The blades are painted red, white, and green, yellow and black, or combinations. As the color of the semaphore blade designates it as a home or distant,

*i.e.* absolute or caution signal, the position of the blade indicating stop or proceed—the color best adapted to local conditions may be used. These signals are used at points where interlocking plants are installed to protect conflicting train movements over intersecting tracks, and therefore are extremely important.

*Block Signals.*—These indicate whether the section of track ahead of them is occupied or not, and are very important signals in this age of limited trains. They are of three general types; in the first, the position, as in the semaphore signal, gives the indication; in the second, the color displayed gives the information; while in the third, the combination of shape and color gives the indication. The colors used in the latter two are red, green, white, and black.

*The Disc Signal,* also known as the Hall and banjo signal, is a type of a color block signal, and consists of white or transparent background before which a seventeen-inch disc of red or green cloth or celluloid is dropped, all mechanism being protected by a wood and glass case mounted upon a pole about eighteen feet in height.

*The Banner Signal.*—This is a type of a shape and color signal, and consists of an oval-shaped white disc with a black background, outlined by a white circle in the proceed position, and a red disc, outlined by a white circle on a black background in the stop position. Drawbridge signals are usually of the semaphore type or may be red balls sixteen to eighteen inches in diameter displayed when the draw is open.

*Moving Signals.*—These consist of red, green, and white flags, sixteen by eighteen inches, waved by trainmen transmitting information to the engine crew.

*Night Signals.*—As the trainmen are almost entirely dependent on signals at night for information as to

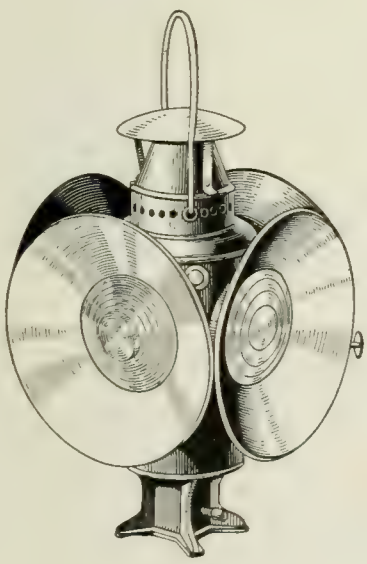

Fig. 1495.—Switch Lamp.

track obstructions, locations, warnings, and means of communication, this is the most important part of railway signaling—it should be the simplest, the surest, and should have the contrast most marked.

The fixed signals are the interlocking signals, block signals, train order signals, switches, classification and rear lights, drawbridge lights, car repair signals, and fusees. The colors used are white, red, yellow, green, and blue.

In all-night signaling, while the color is the main indication, the location of the lights has something to do with determining the meaning of signals, *i.e.* a red light above a white or green light will indicate one thing, and a white or green light above a red light another; hence the necessity for perfect color perception. Yellow is used as a caution signal on roads where green is used for clear. Its usefulness is supposed to be in case a glass should break in any signal, a white light would show when it should be yellow, red or green, and indicates that something is wrong. Drawbridge signals are red and green lights.

Night-motion signals are made with white, red, yellow, and green lanterns swung by hand.

The principles of signal indications adopted by the Railway Signal Association are "on all high signals conferring or restricting rights a *red* light shall be the night indication for stop. A yellow light shall be the night indication for proceed."

Many roads, however, have given up the use of yellow as a caution signal and use green instead; white being the clear indication. Other roads using green as the proceed signal have red and green side by side as a caution indication.

Specifications.—The following specifications for signal roundels, lenses, and glass slides have been adopted by the Railway Signal Association and were furnished by their Secretary C. C. Rosenberg.

*Material.*—Glasses must be of clear uniform solid color, containing the highest proportions of lead compatible with durability and securing the required color and must have a specific gravity of not less than 2.75. Chipped or flashed glasses will not be accepted.

*Workmanship.*—Workmanship shall be of the best, and glasses must be true to size and form, and practically free from bubbles, streaks, and wrinkles.

*Color.*—Red, green, yellow, blue, purple, and lunar white glasses will be purchased.

*Tests.*—(1) The manufacturer must test each glass, placing thereon a label showing the photometric value. (2) The purchaser reserves the right to make tests, and all material not meeting such requirements will be rejected. (3) Red glasses must be submitted to sodium test.

Roundels.—*Design.*—Roundels must be of diameter specified in order, and between twenty-one one-hundredths (0.21) of an inch and twenty-nine one-hundredths (0.29) of an inch in thickness.

*Photometric Values.*—1. Roundels will be subjected to spectrophotometric analysis. The following table gives an analysis of roundels of the various colors of medium intensity, the letters indicating lines of the spectrum and the figures showing percentages of light transmission at the different points. Roundels of medium intensity should transmit light as nearly as possible of this composition, a reasonable variation being allowed for light in dark limits.

| | A | a | B | C | D | E | b | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| Red | 60 | 65 | 70 | 72 | 0 | 0 | 0 | 0 | 0 | 0 |
| Green | 0 | 0 | 0 | 0 | 4 | 27 | 40 | 45 | 25 | 0 |
| Yellow | 0 | 38 | 50 | 43 | 41 | 12 | 9 | 3 | 0 | 0 |
| Blue | 0 | 0 | 0 | 0 | 3 | 4 | 4 | 24 | 40 | 46 |
| Purple | 0 | 42 | 42 | 0 | 0 | 0 | 0 | 2 | 43 | 42 |
| Lunar white | 0 | 62 | 49 | 17 | 15 | 25 | 38 | 65 | 74 | 0 |

2. *Red* shall be of such quality that all yellow rays of light are absorbed, the spectrum being either red or red and orange. The photometric value shall be: light one hundred and thirty (130), standard one hundred (100), dark seventy (70).

3. *Green* shall be of the color known as admiralty green, having a slightly bluish tint. The spectrum

shall show very little yellow, being a full green with some blue. The photometric value shall be: light one hundred and twenty-five (125), standard one hundred (100), dark seventy-five (75).

4. *Yellow* shall give a spectrum showing a full yellow band, most of the red and slightly of the green. The photometric value shall be: light one hundred and twenty (120), standard one hundred (100), dark eighty (80).

5. *Blue* shall give a spectrum having a full blue band, with a narrow band of green. The photometric value shall be: light one hundred and twenty-five (125), standard one hundred (100), dark seventy-five (75).

6. *Purple* shall give a spectrum showing a considerable proportion of both red and blue. The photometric value shall be: light one hundred and twenty-five (125), standard one hundred (100), dark seventy-five (75).

7. *Lunar white* shall show a maximum of absorption for the yellow. The photometric value shall be: light one hundred and twenty (120), standard one hundred (100), dark eighty (80).

Lenses.—*Design.*—Lenses must be of the optical pattern, focusing to a plane rather than to a point, and must be of the polyzonal type, with smooth outer face. All parts of the lens must focus to an area not exceeding three-eighths ($\frac{3}{8}$) inch in diameter for all lenses up to the six (6) inch size, nor exceeding one-half ($\frac{1}{2}$) inch in diameter for the larger sizes; must be so designed that the divergence of the projected beam

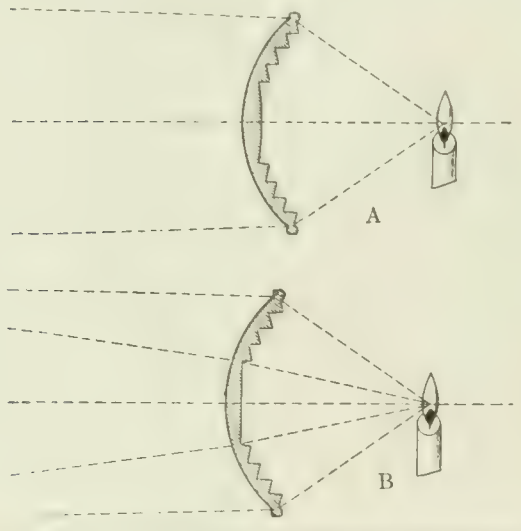


Fig. 1496.—Cross-section of Lenses Used in Semaphore Lamps in Railway Signaling. A, Optical lens; B, wide-angle lens.

(*i.e.* spread), with flame one (1) inch broad, shall not exceed one (1) foot from the axis in eight (8) feet. When observed at a distance of thirty (30) or forty (40) feet, a small flame oil burner being placed in the focus, the whole lens shall be equally illuminated, the "risers" on the inner surface showing only as narrow dark rings.

2. Lenses six and three-eighths ($6\frac{3}{8}$) inches and over in diameter must have at least five zones, and the smaller lenses four (4) and must be corrugated inside.

*Color.*—Colored corrugated lenses must have the same photometric and spectrophotometric values as roundels of the same color, but allowance will be made for divergences due to irregularities of manufacture.

*Focus.*—The focus of each lens must be stamped on the outer zone.

Glass Slides.—*Material.*—The glass must be double thick, and of the same character of material as furnished for lenses and roundels. Thickness of slides shall not be less than ninety-five one-thousandths (0.095) inch and not more than fifteen one-hundredths (0.15) inch.

Since the introduction of the optical lens there have been some variations made due to the varying conditions which the Corning Glass Company have endeavored to meet. Probably the most pronounced is in the inverted lens and cover-glass. The design of this lens is such that there is an increase of fully 50 per cent. in the spread of signal over the standard optical lens which overcomes to a large extent the diminished visibility of signals due to poor alignment of lamps, while the projected light is almost as powerful. Wherever the spread is secured it naturally means a diminution in the projective power.

A committee was appointed by the Railway Signal Association in October, 1904, to make tests and collect data as to (*a*) the design and construction of a lamp for night signal purposes, (*b*) the comparative value in efficiency and candle power between the one-day and long-time burner. It reported in October, 1905, that "the design of a signal lamp should be such as will meet the exacting requirements of present-day railroad service. The question of steel construction is accepted as most desirable, the point at variance being the system or method of ventilation. From experience and tests made, the top draft system is recommended for the following reasons: The maximum signaling power of the lenses is secured at all times regardless of the variations in temperature, as no moisture, frost or ice will collect upon the lenses

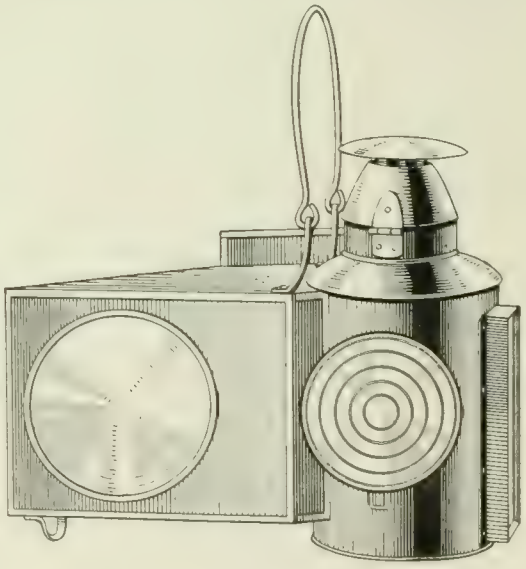

Fig. 1497.—Semaphore Lamp, in which two colors, usually red and green, are shown at the same time as a caution signal.

and retard the passage of light. . . . . While the results mentioned above are of the highest importance in all types of signal lamps, yet they are of especial importance in a semaphore lamp, . . . . . as the light from a semaphore lamp is required to penetrate the roundel in a semaphore arm, a defect of the nature mentioned above becomes especially noticeable and dangerous where frequent high-speed trains are operated."

Relative to the comparative value in efficiency and candle power between one-day and long-time burners, the following are the data concerning the two types of burners in most general use today:

| | Average vertical diameter. | Average horizontal diameter | Average candle-power of naked flame. | Average candle-power with 5½ inch lens | Lens factor |
|---|---|---|---|---|---|
| One-day burner, flat wick ⅝ inch. | ⅛ inch | 1⅜ inch | 1.45 | 55 | 37.9 |
| Long-time burner, ¼ inch round wick. | ⅜ inch | ¼ inch | 0.35 | 50 | 142.8 |

The figures given are the averages derived from numerous tests made at different times.

The results obtained in tests may be summed up as follows: "That a long-time burner in a switch lamp without reflector and in a semaphore lamp with reflector placed back of either a ruby or green roundel cannot be run down in a distance of over two miles and at this distance displays a good efficient signal. (The tests with the red roundel were repeated at a distance of 3.31 miles at which they still displayed a very clearly defined signal. This being the limit of the range, the opinion of all present was that under no conditions would it be necessary to display a signal for so great a distance and the result was considered satisfactory.) Also a yellow roundel can be readily distinguished at a distance of one mile, clearly demonstrating that it is safe to use this color for one of the night indications.

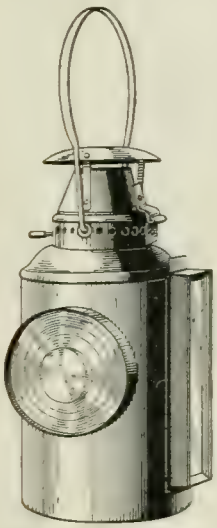

Fig. 1498.—Distant Signal Lamp.

Since the tests made by the Railway Signal Association, Adams & Westlake Company have been gradually developing burners with a larger flame, not so much to get an increased efficiency of signal directly ahead, but by having a wider flame one secures a wider spread of signal and this has been found mainly desirable from the standpoint of assisting in correcting the improper alignment of lamps. The direct candle power ahead, while somewhat increased, is not to a marked degree. Their No. 90 type of burner produces a flame nine-sixteenth inch wide.

In a recent letter the Secretary of the Railway Association states that thus far the Association has not taken into consideration specifications as to the color of flags, classification of rear lights, hand lanterns, or fuses.

Signal observations must be made by the engineman at a sufficient distance within which to control his train.

With the ordinary brakes, seventy pounds trainline pressure, a six-car train running seventy miles an hour can be stopped inside of 2,000 feet, approximately 1,900 feet, and when the high-speed brake, 110 pounds trainline pressure, is used, the train can be stopped within 1,527.25 feet.

It will be seen that the significance of the signal must be determined at not much less than one-half mile (2,640 feet), as a few seconds are necessary for the engineman to shut off his steam and apply his air, and in each one of these seconds a train traveling seventy miles an hour is covering practically 103 feet.

There is no question that next to the necessary practical knowledge of his engine the vision and color preception of the engineman are the most important.

There are so many conditions that severely test the best vision and color sense that a person with these faculties diminished to even a small extent is a source of danger.

Conditions existing about an engine, such as the escape of steam when an injector is used, when the whistle is blown, from leaking valves or connections, from the poorly packed piston rods or air pumps, cylinders, and steam chests, will often completely envelop the engine and cab. Steam and soot from the smoke stack are often blown back against the cab windows, covering them with moisture and dirt and making it next to impossible to see through them, to say nothing of obtaining a view of anything through the condensed steam and smoke. This is especially true in passing through tunnels and under the viaducts or bridges entering the railroad yards of large cities; where there are many moving engines and trains, and signals must be closely watched. In freezing weather the escaping steam is especially bad, as the windows are coated with ice, and vision through them is out of the question. The dust raised by passing trains often coats the windows, especially if they are damp from escaping steam; the engineman's position, being on the right side, escapes most of this, however, on roads which run their trains right-handed on double tracks. The cloud raised from ploughing through snow drifts shuts off all vision for the time. Some considerable complaint is made of the drive wheels of the engine throwing mud and dirt on the front windows in moist weather.

The glare from the furnace door when the engine is stoked makes the recognition of night signals very difficult. There is an iron shield above the furnace door on the engineman's side, which protects him somewhat. Many enginemen have their seats curtained off to relieve them from this glare. After looking into this glow from the position of a fireman during the time required to shovel in five or six shovels of coal, it is an utter impossibility for a novice to read a signal. Firemen state that they cannot even see their steam gauge for several seconds after stoking, and when one takes into consideration that from three to ten tons of coal are handled in a two to five hours' run, there is not much let-up from looking into the fire box, and when this is done daily for five or six years, or even longer, before a fireman can expect to become an engineman, it must be a good pair of eyes that can stand it, without some protection.

The constant jarring, with the swaying and rolling of an engine traveling at a high rate of speed, is another factor in making signal reading difficult.

The constant supervision of an engine takes no small part of an engineman's time and attention, and his duties are far more than sitting on a seat and watching for signals. This is especially true when there is any trouble with the various mechanisms under his care.

Certain atmospheric conditions are not only a source of great annoyance in reading signals, but often completely obscure them at a distance sufficient within which to control a train. Fog, snow, mist, and rain take precedence in the order given, and when it is necessary for better vision to have the head out of the cab window the impinging of fine particles of snow, mist, or rain against the eyes blinds one almost instantly. The force of the wind when running at a high rate of speed causes the tears to flow and blur the vision after a very short exposure. Night (illuminated) signals are usually seen at a greater distance than the day (position) signals in these atmospheric conditions.

Undoubtedly the significance of night signals is much easier determined, as the contrast is so much greater, but as to their being seen any farther, or so far, atmospheric conditions being the ideal, is questionable.

Dusk and early dawn are times of day when signals are most hard to recognize. There is not sufficient daylight to determine the position signals and what

daylight there is seriously interferes with recognition of the night signals.

Thus it will be seen from the factors enumerated above, those requiring good vision and those tending to interfere with it, the best known standard of binocular single vision and color perception is none too good, and not only must a man have this, but it must be "quick vision," for he may for an instant be able to see through some break in the interfering media, and must be able to read his signals in that instant.

Marine Signals.—Signaling in marine service has become a refinement, especially in the Navy, as outside of wireless it is the only means of communication between vessels. The recognition of color is absolutely essential to enable one to understand the various signals.

The signals are fixed and moving. The colors used are white, red, yellow, green, blue, black, and various combinations of the above colors. Day fixed signals in which colors must be recognized are bargees, pennants, and flags, buoys, etc. Bargees, pennants, and flags are of different sizes. The following are dimensions in feet.

| | Size 3 hoist. | Fly. | Size 6 hoist. | Fly. |
|---|---|---|---|---|
| Bargee.... | 7.25 | 7.25 | 2.90 | 2.90 |
| Pennant... | 5.83 | 18.00 | 2.00 | 5 00 |
| Square flag | 7.25 | 7.25 | 2.90 | 2.90 |

These signals are used for communicating in the international code. Storm flags are eight feet square, and pennants eight feet hoist and fifteen feet fly.

"A buoy is a floating object fixed at a certain place to show the position of objects beneath the water, as shoals, rocks, etc., to mark out a channel and the like. . . . . In the waters of the United States the following system of placing buoys as aids to navigation is prescribed by law: Red buoys mark the starboard or right-hand side of the channel coming from seaward, and black the port or left-hand side; midchannel dangers and obstructions are marked with buoys having black and red transverse stripes, and midchannel buoys marking the fairway have longitudinal black and white stripes; buoys marking sunken wrecks are painted green. The starboard and port buoys are numbered from the seaward end of the channel, the black bearing odd and the red even numbers." White buoys are used for special purposes, and yellow marks quarantined grounds.

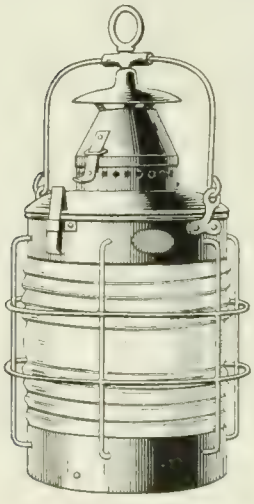

Fig. 1499.—Fresnel Lamp for Buoys.

Moving day signals are the wigwag flags fifteen inches by fifteen inches and the two-arm semaphore flags which are twelve to fifteen inches square. Night fixed signals consist of light houses, light ships, occulting lights, illuminated buoys, ship's lights, electric night signals, Very's night signals, rockets, and drawbridge lights.

White and red lights are used in the United States Light House Service. Ship's lights are white, red, and green. Electric night signals consist of a system of four double lanterns white and red, in which different letters and figures are indicated by the relative position of the red and white lights, shown when reading from above down. Very's night signals is a system whereby numbers are made by red and green lights fired into the air from a pistol; rockets of various colors are used. A blue light burned every fifteen minutes is a signal for a pilot. Drawbridge lights are red and green lights which designate the condition of the draw and position of channel.

Specifications as to the Color of Marine and Naval Signals.—In the United States Light House Service "the red glass used to produce the red lights is of such a shade as to transmit as much of the red end of the spectrum as is consistent and still show distinctly red. Practically this glass transmits

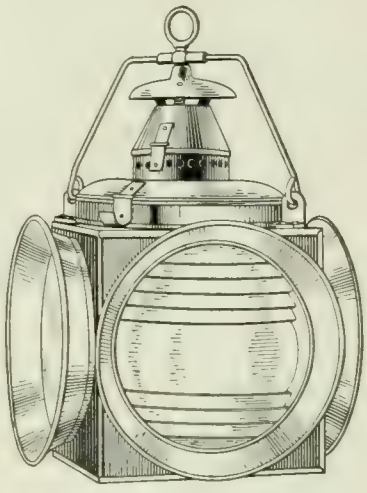

Fig. 1500.—Draw-bridge Lamp.

almost all the red and orange with some yellow and a little green. The specifications for this colored glass call for the transmission of thirty-five to forty per cent. of the light of an acetylene flame." Buoys are sometimes illuminated and exhibit the color red or white to determine their use.

The rules and regulations for preventing collisions at sea (Federal Statutes, Vol. XI., page 154) describe and give certain specifications as to ship's lights and are as follows:

Article 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Article 2. A steam vessel when under way shall carry—

(*a*) On or in front of the foremast, or if a vessel without a foremast, then in the forepart of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, viz., from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

(*b*) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a

character as to be visible at a distance of at least two miles.

(*c*) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(*d*) The said green and red lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

(*e*) A steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

The above rules are general and only a part of the many which apply to vessels of different sizes, and those employed in the various vocations required upon the sea. It will be seen from the above that upon the seas and also for inland navigation a white light must be visible at a distance of five miles and the red and green lights at a distance of two miles; "The word 'visible' in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere."

*Navy Department Specifications as to Lenses*, clear and colored, are as follows:

1. To be of a good quality of lead glass, clear, uniform, and practically colorless, unless otherwise specified, and free from all defects and blemishes which may affect the serviceability or appearance of the lens. To be pressed and to have a smooth surface, true to size, free from bubbles, chippings, streaks, and wrinkles.

Fig. 1501. Cross-section of Lens Used in the U. S. Navy.

2. To be in accordance with plan incorporated in and forming part of these specifications, with respect to dimensions; the actual design of the bull's-eye and corrugations to be at the option of the manufacturer. The top and bottom shall be smooth or ground and at right angles to the axis. Each lens shall be composed of a central zone or bull's-eye, with four zones above and four zones below central zone.

3. The lens must be made of glass which resists the action of salt water without losing its transparency and which has a specific gravity of not less than 2.75. Each lens shall transmit light through its entire surface without the use of reflectors and shall be so designed and pressed that rays of light coming from the focus are projected through an upper and lower arc of at least eight degrees from the horizontal. The center of illumination of the lens shall coincide with its geometrical center. The visibility of transmitted light to conform to international rules, with a navy standard thirty-two-candle-power lamp as the source of illumination, without reflectors.

4. Colored lenses must be solid color, no flashed lenses being acceptable.

5. Green Lens.—The color shall be that known as "Admiralty green," having a slightly blue tint when tested with a Navy standard thirty-two-candle-power lamp as the source of illumination. The spectrum shall show very little yellow, and shall be a full green, with some blue. The total percentage of light transmitted shall not fall below the minimum sufficient to insure a distinct indication at the distance prescribed by the international regulations.

6. Red Lens.—The color shall be of such quality that all the yellow rays of light are absorbed, and the spectrum shall be either red or red and orange when tested with a Navy standard thirty-two-candle-power lamp as the source of illumination. The total percentage of light transmitted shall not fall below the minimum sufficient to insure distinct indication at the distance prescribed by the international regulations. Red lenses not made of lead glass as required by paragraph 1 of these specifications will be acceptable only after same have been tested and approved of by the department. In such cases a sample red lens must be submitted to the construction officer, Navy Yard, New York, unless otherwise directed, for such tests as may be deemed necessary to determine its suitability for naval uses.

*English Board of Trade Regulation.*—The following relative to the lenses, the reflectors, and the color of the glass of the lights used at sea is an extract from the English Board of Trade instructions as to the survey of lights and fog signals.

*Lenses.*—The lenses should be made of crown or flint glass, highly polished, and free from air bubbles or other visible defects. Planoconvex and dioptric lenses should be made as thin as practicable consistently with efficiency and durability.

In order to insure the light being equally visible at all the required angles, it is desirable—

(1) That the lens should be the arc of a circle, and

(2) That the radius which describes it should be measured from the center of the flame, so as to insure the latter being horizontally equidistant from every part of the lens.

The length of the radius may be ascertained from the formula:

$$\frac{\frac{a^2}{v} + v}{2} = r$$

Where a = half the chord of any portion of the arc.
v = the versed sine corresponding to that chord.
r = the radius.

The lens should embrace an angle of not less than 120 degrees, and its height must, in no case, be less than the length of the radius.

The curvature of the outer face of planoconvex lenses and of the respective parts of the outer face of dioptric lenses should be such as to give the desired concentration of the rays of light, subject to the condition that the light must be visible in a clear atmosphere on a dark night at a distance of at least one sea mile, when the lamp is heeled twenty degrees either above or below the horizontal plane.

Lenses having vertical corrugations or ridges on their inner surfaces are objectionable, as the effect of these corrugations is to cut up and obstruct the light and to rob the colored lights of their distinctive color when seen from certain positions. These lenses should, therefore, not be passed in the case of side lights.

*Color.*—It is important that side lights should be of the right shade of color, and patterns of red and green glass of two different tints have been sent to each district for the guidance of the Surveyors. A special shade of green has also been sent for electric lights. (The writer has been unable to obtain the photometric or spectrophotometric specifications of these patterns.)

In the case of oil lamps, lenses or slides of the same tint as either of the standard glasses or of any intermediate tint may be passed as regards color.

In the case of electric lights, the use of lamps of more than thirty-two-candle-power should be discouraged, as they may affect the color. The proper shade of green will probably lie between the darker of the two standard tints and the special electric tint; red lenses or slides of the darker of the two standard tints or of a shade intermediate between the two colors will be found to give a good color.

*Reflectors.*—A substantial metal spherical reflector, silver plated and highly polished, should be fitted to each lamp. Its horizontal axis should be in the same plane as the horizontal axis of the lens, and the radius which describes the arc should be measured from the center of the flame, the length of the radius being ascertained in the same manner as that of the lens, *i.e.*

$$v + \frac{a^2}{2v} = r$$

If these instructions are complied with, the center of curvature of the lens, the center of curvature of the reflector, and the center of the flame will coincide.

The use of binoculars is allowed at sea and is a great advantage in determining signals which is denied railway employees because of the character of their work.

Required visibility of lights.—As noted above the white light must be of such a character as to be visible at a distance of five miles and the red and green lights of such a character to be visible at two miles on a dark clear night.

Atmospheric Conditions.—The atmospheric conditions interfering with the visibility of Marine Signals as with railway signals are often sufficient to completely obscure them from view, but vessels not being of necessity held to a particular course as with a train can receive and give warnings by means of whistles, bells, etc., etc. Fog is particularly dangerous, as the rays of long wave length are the only ones which can penetrate it and an individual with abnormal color vision having a shortening of the red end of the spectrum would be unable to detect the presence of any light made up of wave lengths which escape being absorbed by the fog. Also those who confuse red and green would be unable to detect a green light where atmospheric conditions were such as to filter out the blue, green, and yellow rays and only allow the orange and red rays to pass.

Examinations.—Practically all the railroads of United States and Canada and many of the electric roads have adopted a very thorough system of examining candidates for employment and reexamination of old employees. There has, however, been no uniformity in requirements, each road selecting, or having selected for it by some recognized authority, certain requirements of vision and color perception regarded as safe. The methods of examination and test objects used differ but little, *the lack of uniformity being in what different roads construe as a sufficiently safe standard.*

The committee on safety appliances of the American Railway Association about nine years ago reported unanimously on "Rules Governing the Determination of Physical and Educational Qualifications of Employees." These were adopted by the Association, April 5, 1905, and have not been altered up to the present time.

There was considerable leeway allowed in these rules. This undoubtedly was for the purpose of giving the various roads time to swing into line, as too decided changes could not be expected to be adopted at once, this being the first step of the American Railway Association in this direction.

The rules adopted by the New York Central System, February 1, 1908, are most comprehensive, thorough, and fair to the employees. Those relating to color vision are as follows:

*Rules of New York Central Railway System.*—Rule 1. Each person selected to make examinations must first be examined and instructed by an oculist designated by the Company.

Rule 2. Each examiner should be provided with: A Holmgren or Thompson color-selection test, and instructions for use of same. A "Williams'" lantern, or one similarly constructed, and instructions for use of same.

Rule 3. Examinations should be conducted in a room or car, in which a distance of twenty feet can be measured from test type, or face of lantern, to candidate; shades or curtains should be provided in order to darken the room or car for lantern test.

Rule 4. In testing vision, color perception, and hearing, only the person to be examined and examiners should be in the room at a time, except that if an employee so desires, he shall be permitted to call in another employee who has successfully passed to witness the examination.

Rule 21. Examiners will adhere to instructions laid down by Holmgren or Thompson in using color selecting test, and will examine the color sense of each eye separately. Further examinations will be made with Williams' lantern, or one similarly constructed, in the manner specified by Dr. Williams.

Rule 22. No applicant will be accepted into the service, and no employee retained in any of the classes specified in following standard, who has defective color sense.

Rule 23. No employee will be disqualified from service by reason of defective color sense without an examination by an oculist designated by the Company.

Rule 27. Employees included in the standard of vision must be reexamined as follows: All classes every two years. After any accident in which they are concerned, which may have been caused by defective vision, color sense, or hearing. After any serious accident or illness or severe inflammation of the eyes or eyelids. Before promotion.

Rule 28. Employees in class A or B who are examined by a committee shall be given an outside or field test. A bracket pole with two dolls or two straight poles (spaced the same distance as dolls on the standard bracket pole), carrying four standard semaphore arms and lights shall be used. A clear sky background, tests to be made standing.

In making the test candidates should approach the signals from a point where they are unable to see them and not be credited with being able to read the signals unless they can promptly call changes as made in position of arms, and color of lights.

The test with and without glasses should be made at distances varying from 5,000 to 200 feet.

Committee to record the different distances at which the employee examined can promptly see the signals, and will forward this information, together with their recommendation as to the service to which he may be assigned, to the General Superintendent.

Rule 1. Aims to raise the standard of those conducting the examinations which, in lieu of having an ophthalmic surgeon do all the examining, is a step forward.

Rule 21. Requires examiners to adhere to the rules laid down by Holmgren in carrying out the examination. Holmgren's worsted test and all modifications of it are strictly comparison tests. Its use in any other manner than laid down by its author makes it valueless. It is the failure to carry out the test as directed that causes so many to pronounce it inefficient. The fact that such is the case is sufficient reason for Rule 23, *i.e.* "No employee will be disqualified from service by reason of defective color sense without an examination by an oculist designated by the Company."

Rule 27. Requires the reexamination of all classes included in the standard of vision every two years, and after any accident in which they are concerned, which may have been caused by defective vision, color sense, or hearing.

*Examiners.*—As stated above in rule 1 of the New York Central System's rules, each person selected to make examinations must first be examined and instructed by an oculist designated by the Company. The following from Jennings *Color Vision* is most per-

tinent to such a condition of affairs especially in relation to color perception.

"Railroad Officials, deceived by the seeming simplicity of the method, often allow section foremen to conduct the examination. They receive a small stock of worsted, selected at random, and often proceed to test the color by pulling out a single thread and asking the man to name the color. Even physicians often allow the candidate to critically compare the skeins which in itself should be a sufficient indication of defect." In a report made by committee of the British Ophthalmological Society appears the following: "Your committee becomes more and more convinced that a competent examiner is not made in a day or month, and that even with large experience much judgment and capacity are needful to interpret rightly the acts of the examined."

The following is a description by Dr. W. R. Parker of the car used by the Michigan Central Railway in which visual examinations are conducted: "An ordinary day coach was partially dismantled by taking out all the seats except eight, which are left at one end of the coach to serve as a waiting room. Just forward of the seats fifteen feet from rear end of car, leaving room to pass out of the hallway at the side, a partition is built from the side of the coach to the partition which runs lengthwise of the car twenty-five inches from the side. At a distance of nine feet nine inches from the front of the car a partition is built across from the side to the hall partition, forming a small L-shaped room which is used as a dark room, the windows were carefully covered and an oil lamp was set in a swinging bracket. Doors are so arranged that employees enter the testing room from the waiting room; and after the examination is completed they pass out into the hallway and out of the front of the car, thus preventing intercourse with the unexamined. In testing the color sense in the day time by the use of the Williams' lantern it is necessary to hang the lantern in the dark room opposite the door. By the means of ordinary curtains in the testing room, the room will be made dark enough for accurate results."

The following is an extract from the regulations and instructions in relation to the physical examination of recruits for the enlistment in the United States Navy and Marine Corps: "Color perception is to be always carefully determined. The usual examination is by Holmgren's method, which may be briefly described as follows:" (Then follows a description of the method.) The use of a lantern for testing color vision in the United States Navy and Marine Corps is not mentioned. "No person other than a medical officer will be permitted to conduct any part of a physical examination, to make any measurement, or to make an original entry in any medical record of enlistment."

The Holmgren wool test is used in the English Navy, but the official test of the English Admiralty for color-blindness is the Edridge-Green lantern and is supplied to every one of the final recruiting stations.

Nagel's diagram test is the compulsory official test for the army, navy, and railway service in Germany.

The Board of Trade of England in 1910 appointed the Departmental Committee on Light Tests "to inquire what degree of color-blindness or defective form vision in persons holding responsible positions at sea causes them to be incompetent to discharge their duties; and to advise whether any, and if so what, alterations are desired in the Board of Trade sight test at present in force for persons serving or intending to serve in the merchant service or in fishing vessels, or in any in which those tests are applied."

The report of this committee made in 1912 is divided into five parts. Part I. deals with existing regulations, practice, and results obtained; Part II. recounts experiments conducted in the open air; Part III. considers the degree of defect involving incompetency; Part IV. advises certain alterations; Part V. gives an account of various experiments conducted for the committee.

The Committee summarize their recommendations as follows:

(1) When an inquiry is held regarding a shipping casualty, witnesses who give evidence with reference to colored lights should always be tested for form and color vision.

(2) The approximate limits of color defect compatible with efficiency should provisionally be considered to lie between some such values of the luminosity ratio as 1.5 and 0.85.

(3) The wool test should be modified: (*a*) By substituting a dark brown skein for the third (deep red) test skein at present in use; (*b*) by dividing the skeins into specified groups, one group for each test skein, and requiring the candidate to divide each group into two parts, those which resemble in color the test skein and those which do not.

(4) That the lantern suggested by the Committee be used as well as the wool test.

(5) It is unnecessary to reexamine for color vision a person who has satisfactorily passed both the lantern and wool test.

(6) That the 1911 standard of form vision be adhered to (5/5 partly in one eye, 5/10 in the second eye).

(7) That any officer whose vision in the better eye is less than 5/10 be considered to be incompetent.

(8) Parents and authorities of training ships should be advised that the eyesight of boys adopting the sea as a profession should be examined by an expert (to exclude hyperopia and defects).

(9) That the local tests be left in the hands of the present type of examiners.

(10) That these men should receive a careful course of instruction.

(11) That a distinction be drawn between "ap-

Fig. 1502.—Holmgren Wool Test.

peal" and "referred" cases of failure to pass the local tests.

(12) That an ophthalmic surgeon be added to the present board of examiners in appeal cases.

Tests for Color Perception and Rules for Conducting Same.—The original Holmgren worsteds consist of about 125 skeins of variously colored wools in which are found different shades of red, yellow, green, blue, violet, brown, gray, etc., and three test skeins of light green, rose, and deep red.

*Holmgren Worsteds.* (Jennings: "Color Vision and Color Blindness.") First Test.—The worsted is placed in a confused heap on a large, plane surface, in a good light; the match skein, of *light pure green* (neither a blue nor a yellow-green), is taken from the pile and laid to one side. The candidate is requested to select the other skeins most resembling it in color and place them by the side of the sample. We must explain that resemblance in every respect is not necessary, that there are no two skeins exactly alike, and that an endeavor must be made to find something similar of a lighter or darker shade. He is not to compare narrowly or to rummage much among the heap, but to select with his eyes and to use his hands chiefly to change the position of the selected skeins. If he does not understand, we must ourselves make the trial by searching with our own hands for the skeins. After we have shown in a practical manner what we want him to do we must restore the whole to the pile, except the sample skein. If a large number are to be examined, we can save time by instructing all at once and allowing them to observe the examination of those preceding them. This assists the normal-eyed in making his selection quickly, without, on the other hand conveying any information to the defective by which he can avoid making the characteristic mistakes of the color-blind. A person with a *normal color-sense* will pick out the lighter and darker shades of green rapidly and without hesitation. He may perhaps include in his choice a few green skeins inclining to yellow or blue; but this is no evidence of color-blindness, but rather a lack of practice with colors. The *completely color-blind*, whether to red or green, will select, with or without the greens, some confusion colors—grays, drabs, stone colors, fawns, pinks, or yellows. The *incompletely color-blind*, or those with a *feeble chromatic sense*, will add to the selection of greens one or more light fawns or grays; or they may pick out a skein, hesitate, add it to the greens and then withdraw it, and so on.

When confusion colors have been selected, we know that the candidate is either completely or incompletely color-blind. In order to determine its nature and degree we employ a second test.

Second Test.—The worsted is mixed again and a skein of rose is laid to one side. The candidate is requested to pick out all the lighter and darker shades of this color. The color-blind always select deeper colors. Those who by the first test were found to have a *feeble chromatic sense* will make no mistakes in this test.

The *incompletely color-blind* will match the rose with deeper purples.

The *completely color-blind* will select blue or violet, either with or without purple.

The *completely green-blind* take green or gray, or one alone, either with or without the purple.

The violet-blind show a strong tendency to select blue in the first test, and red and orange, either with or without purple in the second test.

While the diagnosis of violet-blindness is difficult it is also very rare.

As we have decided the character and degree of the defect, it is not necessary to resort to the third test; but as the red skein used corresponds to the danger signal it may occasionally be of value in convincing the officials and other persons that the candidate is unfit for duty.

Third Test.—The sample for this test is a skein of *bright* red, to be used in the same way as the green and rose. The *red-blind* select besides the red, green and brown shades darker than red. The *green-blind* select green and brown shades lighter than the red. Only marked cases of color-blindness will show their defect with this test.

The Departmental Committee on Light Tests appointed by the Board of Trade of England recommended in 1912 that the wool test be modified: (a) by substituting a dark-brown skein for the third (deep red) test skein at present in use; (b) by dividing the skeins into specified groups, one group for each test skein, and requiring the candidate to divide each group in two parts, those which resemble in color the test skein and those which do not.

Fig. 1503.—Thomson Wool Test.

*The Holmgren Worsteds as simplified by Thomson* consists of two different sets of worsteds, which must always be apart, not only in their corresponding part of the box, but also in testing men. The first set consists of a large green sample skein, and twenty small skeins, each marked with a bangle having a concealed number extending from one to twenty. Among these numbers odd ones are different shades of green, while the even numbers are grays, light browns, etc. The second set consists of a large rose sample skein and twenty small skeins which are numbered from 21 to 40. Here the odd numbers are different shades of rose color, while the ten even numbers consist of blues, greens, and grays. The worsted is to be kept from the light in the double box, one side of which is colored green and the other rose, to aid the examiner in keeping the series separate.

In testing, the worsted is taken from the green part of the box and placed upon a table in a confused mass. The candidate is requested to select ten tints to match the large green skein. When this is done and the numbers recorded the worsted is removed and the examiner proceeds with the second set. For the use of the surgical expert two more large test skeins have been added; one, C, yellow, and the other, D, blue. The test C is exposed, and the candidate is asked to match it, if possible, from the skeins 1 to 20. If normal in color-sense he will decline, or at the most only take the yellow-green skein; but if color-blind he will

select a number of the green skeins, which should be recorded. Then use test D, the blue skein, and let him match it from skeins 21 to 40. If normal or green-blind he will select blues only, but if red-blind he will pick out a series of roses, which should be recorded."

*Oliver's Series of Wools for Detecting Color Blindness.*—The test is intended as a ready, and yet strictly scientific clinical test, which can be used for short distances. In this set there are three series of colors:

First.—Five principal test skeins of large size; these are pure colors. Latin names have been employed to represent them. Pure green has been styled "Viridis"; pure red has been termed "Ruber"; pure blue, "Cœrulem"; pure yellow, "Flavus"; and rose, "Rosa." The colors of these skeins are of equal intensities.

Second.—Five small, pure match skeins. Each skein is a pure shade of one of the large skeins; each skein has a bangle containing an inscription which indicates that the attached skein is a shade of one of the principal test skeins fastened to it. Thus for example, in the first series V O I U indicates that the color is a pure green, one shade darker than the larger sample shade of green, the initial letter U designating the word "Umbra," the Latin name for shade.

Third.—Eighteen small confusion skeins, each of which is composed of equal percentages of two of the pure match skeins, the component colors being designated by the initial letters of the colors contained therein, the upper initial giving the preponderant color of the two. Thus, for example, V R U I represents a confusion color composed of green and red, the first color being preponderant in the proportion of two to one; while R V U I is two to one in excess of the red. In this way every color is correlated, thus bringing the match skeins series, both pure and confusion, to one degree of color intensity.

For examination, diffuse daylight is necessary. A square of black muslin is placed upon a table situated at about one meter's distance away from the candidate's eye. The eyes of the subject are to be tried separately. The five large test skeins are separated from the twenty-three match skeins. One of the large test skeins (preferably the green one) is handed to the candidate, and he is requested to select the nearest matches to this skein from the pile of wools, and to lay them alongside of the test wool in the order of their matching. If necessary, the examiner should go through the procedure and show the candidate what is wanted, taking care so to disarrange his choice that it will be impossible for the candidate to gain knowledge from the selection. The letterings upon the tags of the chosen wools are then to be registered in the order of the color choice, upon a properly arranged blank. This finished, the wools are to be replaced among the general mass of wools and the same method of selection continued with the rose, the red, the blue and the yellow series. The procedure does not, as a rule, consume more than a few minutes' time for each candidate. In fact, if care be taken to prevent intercommunication, several candidates may be examined with different sets at the same time.

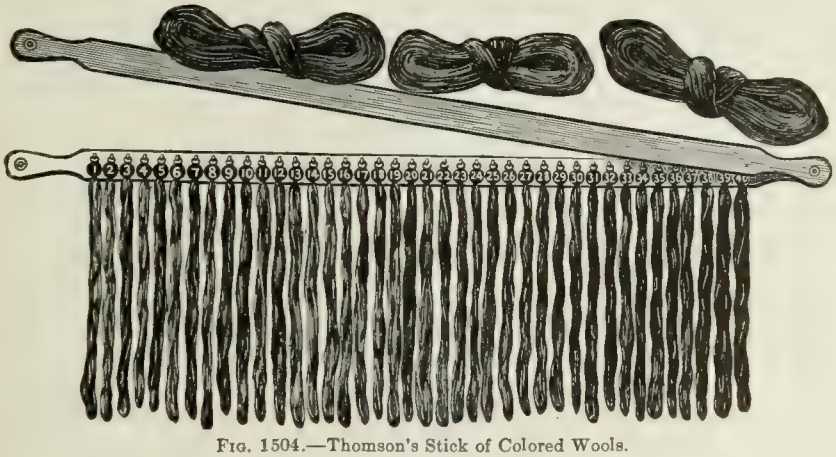

Fig. 1504.—Thomson's Stick of Colored Wools.

*The Edridge-Green Classification Test* consists of four test colors and 180 confusion colors; 150 colored wools, ten skeins of silk, ten small squares of colored cardboard, and ten small squares of colored glass. The whole series of colors is represented, both the simple and modified units. In addition there are a large number of colors which have been chosen by color-blind persons as matching the test colors. The test colors are Orange, Violet, Red, and Blue-green, labelled I., II., III., and IV., respectively. The colors are chosen with the view of presenting as much difficulty as possible to the color-blind, and as little as possible to the normal-sighted. In addition to choosing those colors for tests which are particularly liable to be mistaken for other colors by the color-blind, colored materials of different kinds are used—wools, silks, glass, and cards so as to force the color-blind to judge by color, and not by shade of luminosity.

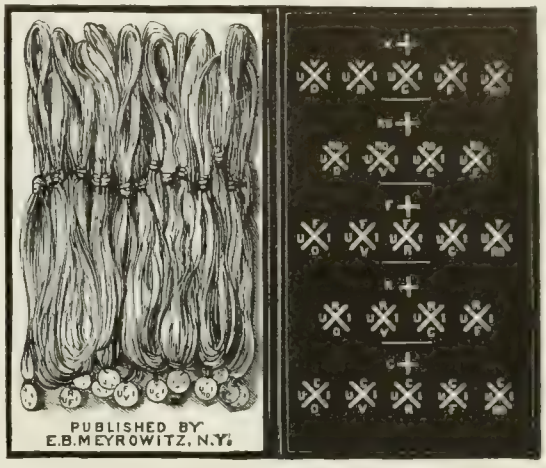


Fig. 1505.—Oliver's Wool Test.

Method of Examination.—The candidate should be given the four test colors, and having named each, he should be told to select all those which are similar in color to the test color. He should be told to pay no attention to the fact of a color being lighter or darker; as long as it is the same color it should be put with the test skein. The examiner should not go through the test before the candidate first of all, neither should one candidate be allowed to watch another making his selection. A shrewd color-blind person might pass the test if he had seen a normal-sighted go through it previously. In order to show the candidate the difference between a shade and color, the examiner should take one of the wools which is not a test color (blue, for instance) and pick out four or five shades of the color. The wools should be arranged without the knowledge of the candidate, so

that a yellow or a gray is placed beside a red and the examinee asked to name its color. At another period of the examination the yellow should be placed adjacent to a green, and the examinee again asked to name it.

The examinee may pick out a certain number of colors correctly, and then stop, saying that there are no more exactly like the test color. This may embarrass the examiner; he should, however, examine any candidate who has omitted any colors as carefully as if mistakes had been made. He should ask the candidate to match one of the omitted colors.

The examiner will soon find out from experience those colors which are named and matched wrongly by color-blind persons; he should ask the examinee to name some of these colors.

Any candidate should be rejected who calls an orange or red, green or brown; black, red or *vice versa;* or green, either purple, rose, red, gray, brown, or violet. Similar mistakes in matching necessitate objection. A candidate who puts purple, rose, or blue with violet, or yellow-brown with orange is most probably dangerously color-blind and should be very carefully examined. Orange is by far the most important test color, and its confusion with green by the dichromics is very conclusive. The three other test colors, violet, red, and blue-green, represent both ends of the spectrum and the neutral point in dichromic cases, and practically these colors are those with which most mistakes are made. This test can only be regarded as supplementary to the Lantern Test.

*The Edridge Green Pocket Test* consists of nineteen cards, on nine of which are 112 single threads of wool, and fourteen pieces of twisted silk, similar to those in the Classification Test. These are numbered consecutively, with the exception of the first thread of the first four cards, and the last thread of the next four cards. The end threads of the first four cards, I. to IV., form the tests; they are Orange, Violet, Red, and Blue-green. There are also cards on which red, orange, green, blue, violet and purple, and gray, respectively, are to be found. There are also two special cards marked "Without Red" and two special cards marked "Without Green."

The cards should be arranged irregularly on a white cloth in a good light. The two most important test colors are the Orange and Violet, Nos. I. and II. The person examined should be asked to point out the shades of color similar to No I. (Orange.) A piece of paper rolled to a point should be used for this purpose. If he do this correctly, he probably possesses normal color-perception. If, however, he match the test with reds or pinks, he is more or less color-blind, at best belonging to the pentachromic class. If, in addition, he match the Violet test, No. II., with blue, he at least belongs to the tetrachromic class. The trichromic in addition may match the Blue-green test, No. III., with brown and gray. The dichromic will match the Orange test, No. I, with yellow-green and yellow-brown. Similar mistakes will be made to those described in connection with the classification test. The examinee should be asked to name all the colors on one of the cards. He should also be asked to point out on which of the cards the four test colors are to be found, and which contain none of the test colors,

The examiner should continually change the order of the cards. Most of the varieties of the color-blind will be readily detected in this way.

The special advantages of this test are: (1) The color-blind can be ranged definitely in their proper classes. (2) Central scotoma can be detected with its aid. (3) The series of colors are arranged so as to confuse the color-blind, while the normal-sighted easily match the test colors. (4) On account of the introduction of different materials, the relative luminosity and saturation of colors does not serve as a guide to the color-blind. (5) Portability. (6) The wools and silks are kept clean. (7) An important color is not likely to be lost.

*Edridge-Green's new test* for color-blindness consists of a number of colored beads in which every variety of confusion color of the color-blind is well represented, and a box with four compartments into which the beads can be dropped. The aperture to each of the compartments is such that the observer cannot see the bead after it has been dropped into the box. The four compartments of the box are labelled red, yellow, green, and blue.

Directions for Conducting the Test.—The examinee is told to pick out from the beads in front of him, which are placed on the white porcelain lining of the box, all those that are red, keeping as nearly as possible to the exact hue but selecting those that are lighter or darker of the same color, and to drop them one by one into the compartment labelled Red. He then goes through the same process with the three other colors; he is not allowed to compare the colors directly but must select them entirely according to the name which he gives to the color. It will be found that while the

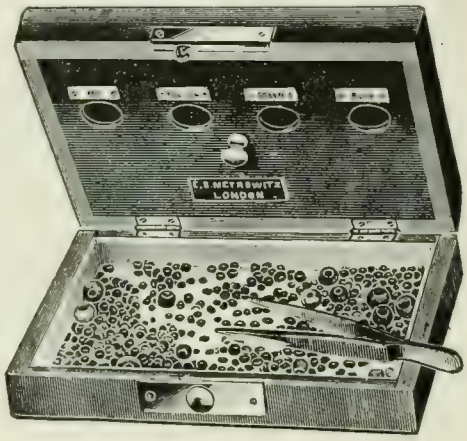


Fig. 1506.—The Edridge-Green Bead Test.

normal sighted are able to select the correct colors with the greatest ease, the color-blind will make their characteristic mistakes. This test like the lantern will detect cases of color scotoma as well as those of ordinary color-blindness.

The *Edridge-Green lantern* consists of four discs: three carrying seven colored glasses and one seven modifying glasses. Each disc has a clear aperture. The other mechanical details are: an electric or oil lamp with projecting accessories, a diaphragm for diminishing the size of the light projected, handles for moving the discs, and the indicator showing the color of the modifier in use. The diaphragm is graduated in respect to three apertures to represent a five and one-half inch railway signal bullseye at 600, 800, and 1,000 yards respectively when the test is made at twenty feet. Three of the discs contain—Clear Yellow, Pure Green, Standard Green, Blue, Purple, Red A, Red B, and one contains Clear Ground Glass, Ribbed Glass, Neutral 1, Neutral 2, Neutral 3, Neutral 4, Neutral 5, smoke glass. The colors are brought successively into view by moving one or more of the handles to position, denoting the color or modifier in use, on the scale at the top of the lantern.

Show each color in one disc, and the modifying glasses in combination, and obtain a name for each.

The candidate should be seated at a distance of fifteen to twenty feet from the lantern. He should be asked to name the color of the light produced by a colored glass alone, or in combination with the modifying glasses or the colored glasses. A candidate should be rejected: (1) If he call the red green or the green red, in any circumstance. (2) If he call the white light in any circumstances red or green,

or *vice versa*. (3) If he call the red green, or white lights black, in any circumstances. A candidate who makes mistakes other than those mentioned above should be put through a very searching examination.

The examiner should on no account conduct the examination on any regular plan, because the candidate anxious to pass, finds out from persons who have already passed, the order and method of the examination; and so, though color-blind, might obtain a certificate. Any one of the slides may be first shown, and the candidate required to name the color of the light. The following will serve as an example of the method to be employed in testing a candidate. The standard red slide having been placed in the lantern, the candidate is required to name its color. Then a blue or green slide may be substituted, then one of the neutral ground, or ribbed glass slides should be inserted; not the slightest intimation being given to the candidate of the nature of the slide. He should be asked to name or describe the light, and the answer, if correct, together with his replies, carefully recorded. The other slides may be shown, a combination of the neutral ground, ribbed, and colored glasses being used at intervals. Twenty correct answers may be considered sufficient for a pass certificate. The procedure should be varied in every case. Questions with doubtful answers should be repeated after an interval of other questions. Answers should on no account be commented upon.

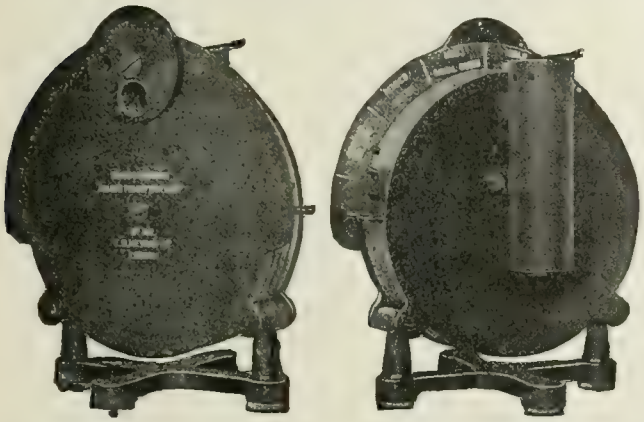

Fig. 1507.—Edridge-Green Color Perception Test Lamp.

Relative to the value of and necessity for the use of color names in a test for color blindness Edridge Green says: "The first requirement of a test for color blindness is that color names be used, and that the person to be examined should employ and understand the use of the color names red, yellow, green, and blue. I can say in the most emphatic manner that no test which ignores color names can be efficient.

"The method of matching colors should, in order to be efficient, be one of mentally naming them. For instance, if a man say to himself, 'This test color is green; therefore I must pick out all the colors having this hue of green in them,' he will go through the test as it should be gone through; but if on looking at the wool he be more influenced by shade, he will put light blues, yellows, grays, and browns with the green. This will be especially liable to happen in cases of the lesser degrees of color blindness, in which the green is simply enlarged and encroaches on the yellow and blue."

"In all my tests for color-blindness I first make certain that the examinee understands what is meant by color. I then make him name a color. It is not necessary that the color names used be those used by me; any name will do. *The essential point is that color-blindness is shown by a person including two colors of the normal-sighted under one name.*"

Edridge Green's Color perception spectrometer is described in the foregoing article on "Color Perception."

*Williams' lantern* has on its face a disc with eighteen colored glasses, and within the lantern two lights and a shutter so arranged that either two or one of the colored glasses can be illuminated at one time. By revolving the disc all the colors can be brought before the lights in succession.

The shutter besides regulating the lights as single or double, also changes the area so that two lights with the full opening, half size, or the smallest opening can be shown, or one light of each of these sizes. Under each colored glass in the disc is an opening with a transparent number, which is lighted at the same time as the color above it, but is screened from the examinee; by means of these numbers a record of the examination can be kept.

The area of the largest opening at twenty feet distance corresponds to the apparent size of a standard switch light at a distance of 160 feet and the smallest opening to such a light at a distance of 1,300 feet.

In the electrically lighted lantern the rheostat permits dimming of the lamps; in the oil lantern the same effect may be gotten by turning the lamps up or down. The lantern is used *in addition to* the Holmgren worsted test.

The rules for using Williams' lantern are as follows: "The room being darkened, light both burners of the lamp and place the lantern twenty feet from the person to be examined, and on a level with his head, the side of the lantern carrying the disc with colored glasses facing directly toward him. Place the sliding shutter, regulated by the knob at the upper part of the lantern, so that two lights are shown at the same time, with the full-sized openings. Ask the person being examined to call aloud the name of each of the colors shown, and designate their positions, for instance, "left green, right red," then turn the disc with the glasses (not too rapidly) until all the colors have been shown. In case it is preferred, the man who is being examined may call out the meaning of the color shown him instead of its name, for instance, "Left Light Starboard, Right Light Port," or, for railway service, "left light safety (if that is its use on the road) or caution, right light danger." The examiner will make note, as the examination proceeds, of the small illuminated number under the color shown, and of the name given to this color thus "9 Green, 11 Red." In case a wrong name is given to any color it is convenient for reference to make a note, on a different part of the record, of this number and its true color. After showing all the colors with the largest opening, raise the shutter so as to show only one light at a time through the smallest opening, and make

Fig. 1508.—Williams' Lantern.

note as before of the numbers shown and the names given to each color. If desired, the colors may be tested through the medium-sized opening, and with one or two lights showing, but it will generally be sufficient, for routine tests, to use first two lights with the largest opening and then one light with the smallest opening.

"If a person calls a red light green, or a green light red, or if he calls a danger signal safety, or a safety signal danger, under any of the conditions of the lantern test, it shows his color perception is so defective that he cannot be considered a safe man for any position where he will be required to use color signals.

"If he calls a green light blue, or a yellow light red, it is not to be considered as a serious mistake; or, if with the smallest opening he cannot see any distinct color in the No. 7 (cobalt blue), which transmits less light than most of the other colors, let it pass without insisting on his giving a name to it, and note on the record under this number, 'No name given'; but a confusion of red and green is fatal."

Fig. 1509.—Thomson's Color-blind Lantern for Electric Light or Candle.

*The Thomson lantern* for detecting color-blindness consists of an asbestos chimney which can be placed on a kerosene lamp in universal use on railroads, or over an Argand burner or other gas light, electric lamp or spring candle stick.

There are two discs three and one-half inches in diameter, each containing seven openings which carry the colors, which revolve over each other so the colors may be seen separately through the opening at which they are presented, or be superimposed.

The openings in the discs where the colors are shown are one-half inch and one-twelfth inch in diameter, and are made of the size to simulate signals at different distances. Taking Donders' formula for measurement of color perception, the small opening of one-twelfth inch, when placed in front of a color, is equal to normal color vision at thirty-two feet. The one-half-inch opening is equal to normal vision at 200 feet and for practical purposes the one-half-inch opening at twenty feet is equal to the ordinary five-inch semaphore light at one-half mile.

The lower disc contains the standard colors used as signals on the railroads: red, blue-green, blue of the inspector's light, and yellow. This disc is known as the examination in chief.

The colors have been carefully selected and are identical with the standards used on the railroad when shown in the lantern. These colors are designated by numbers, 1 to 7.

The upper disc contains the confusion colors, and the small opening of one-twelfth inch which is used as a quantitative measure of color perception. This is known as the cross-examination and its colors are designated by letters of the alphabet—A, B, C, etc.

The colors of this disc are pink, yellow-green, cobalt, deep London smoke, and gray-ground glass and are the most important in detecting the different types of color-blindness, and especially those varieties that are not perfectly determined by the wool test. For example, the three colors, pink, yellow-green, and gray-ground glass are the typical neutral colors of the color-blind and represent the confusion colors of the wool test. The pink, which to the normal eye appears light red, is composed by the spectroscope of pure red and blue. This cannot be imitated in glass, so it is made of a piece of colored gelatin and placed between two layers of glass. If this color is regarded through a piece of peacock-blue glass, cutting off the red it appears blue. The normal eye sees it as light red, the red-blind man, having his red sensation defective, sees only the blue and as these three colors, pink, yellow-green, and gray, are the color-blind man's white, so the pink may be mistaken for white; the same holds good with yellow-green or gray ground glass, which may be mistaken for white, red, or green. It will be found in the practical examination of one who has a defect in his color sensation that these three colors are invariably designated as the same color; the only distinction he makes is that they are different shades of the same color, while to the normal eye they are three distinct colors.

The London smoke is used to reduce the intensity of the color and for practical purposes simulates the changes that take place in the atmosphere, rain, fog, etc. The cobalt transmits both red and blue and is also a good test and at the same time when used with other colors, makes valuable combinations.

By being able to superimpose the colors one over the other one is able to get not only a considerable variety of different colors, but many shades of the same color, for example, seven shades of red, ranging from an exceedingly dark red color that might be represented by a lamp burning very low, up to a very light pink. These can all be shown in rapid succession.

The addition of the corrugated lens in the present lantern is of great improvement. It overcomes the former difficulties by giving a uniform opening and at the same time does not reduce the intensity and saturation of the color, and secondly the corrugations of the glass being very small, is practically a miniature semaphore light, and acts precisely the same at the distance we use it, as the railroad semaphore.

In the lantern only one color at a time is presented for examination, and in this it differs from some other lanterns which are now in use. The colors are named or their indication specified.

*Nagel's card test* consists of "a set of cards, each bearing a series of little color discs arranged in a ring. In some rings the discs are all one color, but of slightly

different shades; in others the discs are of two or three different colors (confusion colors). By making the patient state which rings are monochromatic and then make him pick out in the dichromatic or trichromatic rings all the discs that are of one special color, we can readily ascertain whether he is color-blind and what sort of color-blindness he has."

*Stilling's Card Test.*—The Stilling plates are ten in number, each plate containing four squares filled with small colored spots, among which other spots in a confusion color are so arranged as to represent a letter or figure.

Stilling was aided in the preparation of these plates by a red-green blind painter and a blue-yellow blind teacher and in this way he built up two classes of interchangeable colors.

First Class.

Fiery red, interchangeable with dark yellow.
Intense green, interchangeable with dull loam color.
Faint rose, interchangeable with bright gray.
Faint blue-green, interchangeable with bright gray.

Second Class.

Fiery red, interchangeable with intense gold-yellow.
Greenish yellow, interchangeable with faint bright blue.
The last two, interchangeable with bright gray.
Green, interchangeable with blue.
These two, interchangeable with dark gray.

In using this test, "the test plate is held in a good light and the candidate required to distinguish the letters or figures. An important feature of this test is that there is no inquiry as to color, but only as to letters and figures."

*W. Meyer's test* consists of a square of red paper with a gray border, the whole covered with a piece of tissue-paper. To the normal eye the border appears green, complementary to the color of the square. "A color-blind person who does not recognize the color of the square will not be able to tell the complementary color of the border."

*Cohn's test* is based upon Meyer's tissue-paper contrast. On a red background, a number of curved, hook-like figures, opening in different directions are outlined in black; when tissue paper is placed over this table, the hooks appear green to the normal eye on the contrasting background. The normal person can therefore see these hooks and tell in which direction they are turned; but the color-blind cannot perceive them.

*Oliver's modification of the Abney pellet test* for detecting color scotomata consists of a wooden disc, upon the upper surface of which definitely tinted spherical pellets are loosely laid, the whole being covered with a transparent lid. The disc which has been painted dead black and which is ten centimeters in diameter, is constructed like a planoconcave lens, with its upper concave surface made equal to the curvature seen in a minus spherical lens of four diopters strength. The lid, which is of clear plane glass, surrounded by a beveled rim of blackened metal, is hinged upon the disc base and is fixed in position by a metallic push spring-clip. The pellets, each of which is four millimeters in diameter, are composed of ivory, and are definitely gauged in their relative tintings to equal degrees of color saturation.

A pair of ingeniously contrived forceps so fashioned that each pellet is most easily held in position when once grasped, accompanies each box.

The plan of procedure is to employ but one eye at a time, taking care that the unused one is excluded from participation in the test. The apparatus, placed upon some broad black surface such as a large dead black table cloth, is then brought into view.

The green pellet is removed from the rest of the colored pellets in the color tray and laid upon the cloth alongside of the forceps. The color tray with the remaining pellets is left open and exposed. The patient is shown the separated pellet and the forceps. Nothing is said to him in regard to the name of the tint or the color. He is then requested to pick up the pellet with the forceps and hold it in the position before him at which it seems the brightest and the plainest. If he holds it eccentrically or turns his head to one side in order better to see the pellet, his defect will become quite evident. He is then asked to hold his head in such a position that his exposed eye is situated at some forty to fifty centimeters distance directly above the color tray. While in this situation he is made to drop the pellet among its fellows in the color tray. The moment that the pellet has been placed in the tray the box is given a slight twist so

Fig. 1510.—The Oliver-Abney Pellet Test.

that the pellet will be made to assume new relative positions. This done, the patient is requested to select the pellet from among its companions. If he has a central scotoma for green of but a couple of degrees in diameter when the test tray is held in this position, it will be almost impossible for him to regain the green color pellet—thus again objectively showing the central field defect for the perception of green and at the same time objectively proving its existence. The test is to be repeated with the fellow eye, and if desired, with the red, the blue, and the yellow series of pellets.

*Rayleigh's color-mixing apparatus* necessitates matching the sodium D light of the spectrum by a mixture of red and green light. There are different instruments used for the purpose. (See description of Nagel's anomaloscope). The quantities and intensities of the red and green light required by the candidate to match the yellow at the D line of the spectrum are noted.

*Nagel's anomaloscope* is an instrument for making the Rayleigh test. It "serves, as the name suggests, not only to unmask color-blindness (dichromatism), but also to detect anomalous trichromatism. The anomaloscope consists essentially of a telescope, in which the examinee sees a small circular field. The field is divided into two by a horizontal line. The lower half obtains its light from a prism which is so adjusted that only yellow (sodium light) illuminates it. This is done by a screw, which is called for convenience, the 'yellow screw.' If the scale attached to the screw stands at zero, the field is quite dark, 88 indicates its maximum brilliancy. It is therefore possible by turning the yellow screw to vary the brightness of the lower field between the widest limits. The color, however (sodium yellow), remains constantly the same.

"The upper half of the circular field is simultaneously lighted by two prisms, one of which is adjusted to furnish green light (thallium green) the other red light (lithium red). In this case, also, slits are placed behind the prisms which can be adjusted at will either fully opened or quite shut. But it is only possible to alter the two slots simultaneously, and their motions are complementary in the sense that as one opens the other shuts in an equal degree.

"In this way it is possible to modify the light mixture as desired. Any mixture of red or green may be made or either color entirely cut out. The slits

are adjusted by a screw which is called the "red-green screw." The milled head of the screw is graduated from 0 to 88. If the pointer stands at 0 the field is pure spectral green, if it is turned red is introduced. The more red is added, the more colorless the green, until at a certain spot (fifty-eight on the scale) the upper half of the field becomes a colorless yellow, neither green nor red. As the screw is turned the upper field takes on a red tone, which becomes more marked, until ultimately all the green is shut out and the field is a pure spectral red.

"As just stated at a certain position of the red-green screw (that is to say, with a definite mixture of red and green) the upper field becomes to a normal eye colorless with a yellowish tone. It is now possible to modify the intensity of the lower field by turning the yellow screw until both fields have the same intensity. In other words, a match can be made between a yellow light of a certain brilliancy and a mixture of pure spectral red and green. This is the well-known Rayleigh equation. This match is made for a normal individual when the yellow screw indicates 14, the red-green 58. To discover with the anomaloscope whether anyone has a normal trichromatic color system it is only necessary to fix the yellow screw at 14, and ask the examinee to make the match by turning the red-green screw. If he places it at 58 he has a normal color perception. But this limit is not mathematically exact. More often a slight variation is found which may extend from one to two marks on the scale of the anomaloscope or even three or four on one side or the other of 58, without in any way showing color weakness. Such small variations must be regarded as being within the physiological limits of normal color perception. The fact that a normal person who matches at 58 sees a distinct green or red when he turns three to four divisions to the right or left does not alter this view at all. Nor is the fact of importance that those who make a match at 54 to 62, when they look at a match made by a normal, see the upper field decidedly red or green; that is, in other words, they reject the match made by the normal eye . . . . .

"But for practical work a definite limit is required. This must be empirically found and determined. It is suggested that on an anomaloscope whose equation figures for the normal eye are 14 and 15, the limits should be 54 on the green side, and 64 on the red side. Everything within these limits is to be regarded as normal. Köllner has laid the limits down at 56 and 64. It is, however, considered safe to go up to 54 on the green side. All the examinees who match between these limits are as a rule able to read Stilling's tablets easily, and make no mistake with Nagel's test. They are only a little uncertain between green and gray. The confusion between green and gray is so common that Nagel himself has explained that the mistake was only of decisive importance when the examinee did not recognize his mistake when his attention had been drawn to it. Experience shows that anomalous trichromatics generally choose values which are widely outside the limits chosen above. Thus abnormal reds generally placed the index at 70; abnormal greens, below 45.

"The anomaloscope is also of value for the diagnosis of protanopia and deuteranopia. To examine these anomalies, place a pure red in the upper field of the instrument. Both protanope and deuteranope see this in a warm tone . . . . . Both of them can by turning the yellow screw adjust the lower field of the anomaloscope until it matches the upper. Thus both protanope and deuteranope will make "a match between red and yellow." It is easy by the position of the yellow screw to discover whether one is dealing with protanopia or deuteranopia . . . . . Analogously the protanope and deuteranope can match pure spectral green with yellow . . . . .

"Certain precautions are advisable in using the instrument. It is possible that dichromatics and extreme anomalous trichromatics may make the Rayleigh match either correctly or nearly so. This point demands the closest attention. Examination by the Rayleigh equation alone will fail to discover a large number of these anomalies. This may be avoided if the candidate is first examined with Nagel's or Stilling's plates, and the examination by the anomaloscope is begun with a search for dichromacy."

The Departmental Committee on Light Tests appointed by the Board of Trade of England recommend "That the lantern suggested by the Committee be used as well as the wool test." This is a paraffin lantern showing red, green, and white which shows one or two small lights simultaneously; these are reflected from a mirror without means of regulating the intensity of the illumination.

Adequacy of Various Tests.—It is generally conceded among ophthalmologists and physicists that the Holmgren and other wool tests carried out as directed by their authors are not reliable tests and will exclude individuals who have normal color perception, at least a large number of candidates have been rejected because of faulty selection of the wools who have upon appeal been subsequently passed after a careful examination by an expert. It has also been shown conclusively that the Holmgren test misses about one-half (or according to German authorities more than one-half) of those who are dangerously color-blind and are at once detected by use of one of the various forms of lanterns for detecting color-blindness. The Holmgren wool test is criticized as being unfair in that it is too arbitrary and involves processes with which a candidate is absolutely unfamiliar and the verdict depends largely upon the tact, patience, or ill will of the examiner. This test when carried out according to directions is lacking in one of the first essentials of a test for color-blindness, *i.e.* that color names should be used and that a person to be examined should employ and understand the use of the color names red, yellow, green, blue, and white. Edridge Green says, "The method of matching colors should, in order to be efficient, be one of mentally naming them. For instance, if a man say to himself, "This test color is green; therefore I must pick out all the colors having this hue of green in them," he will go through the test as it should be gone through; but if on looking at the wools he be more influenced by shade, he will put light blues, yellows, grays, and browns with the green. This will be especially liable to happen in cases of the lesser degrees of color-blindness, in which the green is simply enlarged and encroaches on the yellow and blue." It is not necessary he goes on to say "that the color names used be those used by me; any name will do. *The essential point is that color-blindness is shown by a person including two colors of the normal-sighted under one name.*"

The pseudoisochromatic tests such as Stilling's and Nagel plates have occupied a first place in tests for color-blindness and as Edridge Green states "If cases of color-blindness were identical these methods would be more reliable than they are. Cases of color-blindness however differ; in fact it is difficult to find two cases exactly alike. If a pseudoisochromatic match be found for one dichromic and letters of the one color be printed on a background of the confusion color he will not be able to read them. Another dichromic, however, may be able to read these letters quite easily. For instance, he may have much greater shortening of the red end of the spectrum, and the subtraction of the red rays from one color will make that color much darker than the other color confusion. On account of the fact that simultaneous contrast is increased in the color-blind, it is necessary that both colors of confusion should correspond to two points well within the monochromatic regions of the observer. These are the main objections to pseudo-

isochromatic tables, if we exclude the extreme difficulty of accurately producing them. Quite apart from this the fact that the two colors are regarded as identical by the color blind can be utilized in a far easier and more satisfactory manner."

Marshall states that "the test with Nagel's anomaloscope is hopelessly inadequate because many normal-sighted people vary greatly in the proportions of red and green which they use in order to produce yellow, while many color-blind people make the match with precisely the same proportions as the majority of normal-sighted people." Further "in a recent paper before the Royal Society, Edridge Green showed that color-weakness and anomalous trichromatism are not necessarily associated, and if this be so the test fails at once."

As regards lamp or lantern tests the consensus of opinion seems in favor of them inasmuch as the examination of a candidate by means of them shows conclusively whether he can name and distinguish between the colors of the lights which he will be required to recognize in pursuit of his duties in Railway and Marine service.

The use of any of the color-matching tests is as a rule supplemented by other tests such as the anomaloscope, Rayleigh's matching lantern, or the various lanterns in use. NELSON MILES BLACK.

**Colorado.**—The State of Colorado embraces about twice as much territory as the whole of New England. The western two-thirds of the State is covered by a portion of the Rocky Mountain system, while the eastern one-third consists of the western margin of the Great Plains which gradually ascend in height from 4,000 feet on the eastern border of the State to 6,000 feet where the foothills of the Rockies begin. The foothills with their adjoining valleys vary from 6,000 to 7,000 feet in elevation.

Westward of the foothills are the natural parks, standing at altitudes between 7,000 and 10,000 feet, interspersed among the mountains of which in Colorado there are 130 peaks ranging from 13,500 to 14,500 feet.

The eastern or plain portion of the State consists of elevated plateaux which are for the most part barren of trees and vegetation save for the native buffalo grass, and the streams are few and small. This region is uninhabited except in the few widely scattered ranches and small towns.

A few miles eastward from the foothills, along the margin of the plains where they approach the mountains, are situated the most prosperous and populous towns in Colorado, and it is on this strip of land that most of the invalids locate. In the northern portion of this area, on the plains some fifteen miles from the foothills, stands the city of Denver, the capital of the State, while seventy-five miles to the south of it, and only five miles from the mountains, is Colorado Springs with its suburbs. Forty miles to the south is the manufacturing city of Pueblo, and still farther, on the borders of New Mexico, is the city of Trinidad with its important coal mines.

To the westward, in the valleys among the foothills, are found the smaller towns of Boulder, Golden, Manitou, and Cañon City.

The mountain parks are used in the summer by invalids, some of them (especially Estes Park and Manitou Park) being well supplied with accommodations for visitors. On the western side of the Rockies are many prosperous towns, which are not as much used by invalids as those of the eastern slopes because of the climate being less dry. Glenwood Springs, however, is a place much frequented by the sick, though not usually by those who are tuberculous. The varied topography of the State naturally gives rise to variations in climate, though all share in the common attributes of sunniness, dryness, and diminished barometric pressure. In the eastern or plain portion is to be found the most sunshine and least humidity, but with more dust and wind than in the sheltered valleys and parks of the mountain regions. The average annual rainfall is fifteen inches. The range of the greatest annual extremes is not more than ten inches, while on the coast of California it extends to thirty-nine inches. The rain is naturally more copious on and near the mountain peaks, and at this great height it usually though not invariably increases with the altitude. On the eastern side of the main range the bulk of the precipitation occurs during the summer half of the year, there being no rain through the winter and very little snow. On the western, or Pacific slope, on the other hand, the precipitation during the winter six months is somewhat greater than in the summer. The mean relative humidity of Colorado is 50 per cent., and the actual humidity 2.04 grains per cubic foot of air, the average annual temperature being 50° F. This dryness of the air causes both the heat and the cold to be better borne for reasons which are so well explained by Professor Harrington in his paper upon sensible temperatures to be found in the transactions of the American Climatological Association (vol. x.).

"The sun in Colorado, in that great tract along and among the eastern foothills, in which are located Denver, Colorado Springs, Manitou, Pueblo, Trinidad, Golden, Boulder, Fort Collins, and Greely; in that region to which the tourist and the invalid are most likely to come, and in which they are likely to stay longest—the sun here shines for about sixty-two hours out of every hundred in which it is above the horizon. In Philadelphia the ratio is forty-nine. During the winter months, the trying time for the invalid, the difference is more striking still. In Colorado we have from December to March, fifty-six per cent. of all possible sunshine. In Philadelphia they get but thirty-seven per cent.; a difference in Colorado's favor of over one-half. In ten years there were in Denver, on the average in each year, 314 clear or partly clear days. In Chicago, in the same period, there were only 251; in New York, 262. During the three winter months the sun shines four out of every five days. Nor do these figures tell the whole story. One of the greatest advantages of this eastern belt along the front of the range is the early morning sunshine. There are no high mountain ranges for the sun to climb as in so many high altitude resorts in other lands, but its first rays above the low eastern horizon are at once warming and cheering. The sun is up before the invalid is awake, and the air is warmed for his outdoor life without a long wait till mid-morning. In Davos, Switzerland, the sun on January 1 does not rise till 10 A.M., and sets at three in the afternoon, a possible sunshine of only five hours. In Denver on January 1 the sun rises at 7:30 A.M. and does not set till after 4:30 P.M.: more than nine hours of sunshine. Neither do the few cloudy days preclude an outdoor life. They do not bring the damp and rawness of the Eastern or Middle States." (J. C. Dana and C. E. Edson: "Colorado, about Its Climate.")

The temperature of the air in the sunlight and in the shade varies from 40° to 60° F. There is a large amount of electricity and marked diathermancy of the air.

The wind movement of Colorado is high, especially on the plains, though it is not as high as that of the most important cities of the Union.

Through the country, where the plains and mountains meet, the seasons may be thus briefly described: March is usually dry and a pleasant month with but few storms. April is, perhaps, the most disagreeable month of the year, as in the first half wet snow storms or heavy rains are usual. In May the weather improves, and in the last half of the month it is

generally good. June is dry and warm. Through July and August the summer heat is not excessive, the mornings and evenings being bright and beautiful, while in the afternoons heavy thunder showers lasting some twenty minutes are usual. By the middle of September the rains have ceased, and beautiful, dry, sunny autumn weather is experienced usually until the turn of the year. In January and February the coldest weather occurs, but as it is dry, clear, and sunny it is bracing and pleasant, except to those who are too feeble to react to its tonic effects.

Boulder—elevation 3,500 feet, population 12,000, including its additions; latitude 40°. This town is situated at the mouth of Boulder cañon some thirty miles northwest from Denver. The State University of Colorado is here, and there is also a sanatorium which is a branch of the Battle Creek sanatorium. Comfortable accommodations can be obtained at the hotel and boarding-houses. There is a good municipal water supply and excellent sewerage, lighting and street railway systems. The mean temperatures (Fahr.) as recorded are spring, 49°; summer, 65°; autumn, 49°; winter 24°. Total rainfall, 19.21 inches: spring, 8 inches; summer, 7.7 inches; autumn, 2 inches; winter, 1.51 inches. The humidity and wind movement observations are not to be obtained. The soil is sandy.

Cañon City—elevation 5,300, latitude 38° 30′; population 6,000. Cañon City is situated at the extreme western end of the Arkansas Valley, at the mouth of the famous Royal Gorge. It is forty miles west of Pueblo, on the main line of the Denver and Rio Grande Railroad, and a branch of the Santa Fe Railroad from Pueblo. It has a milder winter climate than the cities on the plains. This is due largely to the shelter from the wind afforded by the surrounding mountains, which rise from 2,000 to 3,000 feet above the town and protect it on the north, west, and south. To the east the valley opens to the plains. Snow fall is light and quickly disappears. The soil of the valley is adobe on the north and sandy loam on the south side of the river. The city is supplied with electric lights, gas, waterworks, and sewer system. The water supply is taken from the Arkansas river and passed through sand filters. It is pure and of excellent quality. There are good hotels and boarding houses. There are hot and cold soda springs on the edge of the city. The seasonal temperatures (Fahr.) rainfall, and number of rainy days are: Spring, temperature, 52°, rainfall, 4.2 inches, number of rainy days 16; summer, temperature 72°, rainfall 4.2 inches, number of rainy days, twenty-four; autumn, temperature 53°, rainfall 1.6 inch, rainy days nine; winter, temperature 34°, rainfall 1.8 inch, rainy days eight.

Colorado Springs—elevation 6,000 feet; latitude 38° 51′; population 29,078. Colorado Springs is situated seventy-five miles south of Denver on the mountain shore fringing the ocean of the Great Plains. "These plains, which begin to rise 800 miles away to the eastward and stretch an equal distance north and south, have been called the Great American Desert. This great plateau is almost completely barren of trees and crops, and is traversed by a few slender streams. The arid soil yields but little water from infrequent wells and springs, and the dry air blowing over this plateau gives but scant moisture; so that there are only a few scattered oases of cultivation in this vast expanse of grassy plain. To the eye the rolling prairie conveys the impression of the sea, and, no doubt, it was this thought that prompted the early pioneers to call their wagons as they slowly lumbered over the plain 'prairie schooners,' the wagon covers in the distance resembling sails.

"The town has in the west, towering eight thousand feet above it, that great sentinel of the Rockies, Pike's Peak, with its shoulders sloping to the lower heights of Cheyenne Mountain in the south and melting into the Front Range in the north, with a spur, the Divide. This Divide projects from the front range to the eastward, its crest being twenty-five miles north of the town, and curving southward; it therefore shelters the city on the north and east. These mountains and their spurs form a semicircle. The town situated in the depth of the curve lies, as it were, in a bay opening southward to the ocean plain." (S. E. Solly: "An Inland Seashore," *Mountain Sunshine*, vol. i., 1899, Fall number, p. 2.)

In looking landward from the town it will be noticed how it is encircled by ramparts formed by the ground rising from 6,500 feet on the east up to 7,000 feet on the north, and sloping upward along the western line to over 14,000 feet upon the summit of the Peak and southward again to the 6,500 foot level. The ramparts formed by the mountains afford shelter from the sweep of the continental storms and by their attraction keep back much of the rain and snow that gather around the Peak. The lofty eminence of this grand mountain, piercing the upper cooler strata of the atmosphere, draws toward it the clouds which, as they break, pass southward over Cheyenne Mountain and northward over the Front Range, and thus eastward along the ridge of the Divide.

The heavy trans-continental storms coming from the west over the mountains, for the most part, do not strike the plains short of fifteen miles to the eastward, because of the great width of the angle at which they descend by reason of their great velocity and the height of the mountains they have to cross, thus leaving the town in the wind-shed below. This sheltered position does not, however, prevent the town from experiencing on these occasions much movement of the air from the eddying currents set in motion by the storms that pass over and around it.

Perhaps one of the strongest features in the resemblance to a seashore is in the customary daily variations of the local winds. Wherever the land and ocean meet there is a daily breeze blowing from the sea to the land and a nightly one from the land to the sea. Here we have in the diurnal winds an exact counterpart of the sea and land breezes. In ordinary weather, throughout the night, a gentle breeze blows from the north and northwest, and as the sun begins to rise the wind shifts eastward and, passing south, blows from the southwest during the early afternoon; then turning backward through the eastern quarter it reaches the north once more as the sun goes down, where it lingers through the night. The velocity of the wind is very slight during the hours of darkness, but increases after daybreak up to two or three o'clock in the afternoon when it blows with its maximum force, gradually dying down again as sunset approaches and it returns to the northern quarter. Thus we have by day a sea or plain breeze, by night a shore or mountain breeze.

The customary winds are, however, very different in their quality from those on the seashore, because they are dry instead of moist. This is particularly the case in contrasting the sea and plain winds. The winds passing over the ocean toward the shore must, from the very nature of things, bring with them much humidity, so that in whatever climate a sea breeze blows it is always damp and there can be only relative dryness in sea breezes, but owing to the varying temperatures its effects may be very different. For instance, on a seashore where there are brilliant sunlight and genial warmth, as on the coast of Southern California, through the warmer hours of the day the sea breeze blows and does not part with its humidity as rain or fog. During the early morning and evening hours the change of temperature is usually too slight to cause a fall of rain, but the moisture in the air condenses to a light fog. This condition is practically the same both summer and winter

in California, but on the North Atlantic coast the conditions are only similar during the summer, while in winter the greater cold brings harsh weather with increased precipitation. The great and important difference between this fancied seashore and a real one is that it is dry instead of moist, though they are alike in this, that breezes bring an abundance of pure air which has blown over surfaces untainted by malaria or the habitations of man. It is the proximity of the great plains with their dry, treeless, and sparsely populated soil that gives to Colorado Springs such a magnificent reservoir of pure, sun-dried air for it to draw upon.

The open aspect to the south and east with the sloping southern shoulder of the Peak, allows longer hours of sunshine and intenser light than are found in the Swiss mountain valley resorts. For instance, on the first day of January the possible hours of sunlight in Davos are four hours, whereas in Colorado Springs they are nine.

In the Alpine valley resorts the daily breeze blows more gently over chilly mountain tops or ice fields, bringing a much cooler and slightly damper atmosphere than that which reaches Colorado Springs from the plains. While the qualities of the Colorado Springs diurnal winds are suited and agreeable to many, yet for others the greater coolness and lesser velocity of the daily breeze experienced in Davos are to be preferred.

The plateau upon which the town stands is composed of sand and gravel, rising some seventy feet above the clay bed of the streams. In this soil no water is to be found and the city is dependent upon water brought from the mountains. The surface of the plateau thus lifted above the river valleys is level and has a gentle slope from north to south, which allows good natural drainage and easy sewerage. When one is standing on the town site, the elevation of this plateau above its immediate surroundings conveys the impression of height; but on looking down upon the town from the encircling benches or hills, we then see that it really rests in the hollow of a bay with two sheltering arms stretching out from Pike's Peak around it to the north and east, and to the south and west, leaving the southeastern aspect open to the plains.

Occasionally during the winter half of the year the wind will remain throughout the day in the northern quarter, bringing cold, stormy weather from across the mountains; though when the thermometer drops near or below zero, as it occasionally does, the wind usually also abates, so that the intense cold is quite endurable and even pleasant if the body is well protected by warm clothing. It is also a rare day when the sun does not shine. During the nights, which are usually the coldest portion of the twenty-four hours, there is rarely much wind blowing. After a cold snap, when snow has fallen, often the chinook—a warm, dry wind which rapidly melts the snow and dries the ground—will blow from the west. It is similar to the föhn wind of Switzerland, which is sometimes called "the snow eater." The velocity of the chinook is very great, but it rarely blows more than a few hours at a time. Winds from the west and southwest are infrequent, but in addition to those which have been mentioned occasional local breezes will spring up, blowing from the west, but not of high velocity or of long duration.

The mean total monthly wind movement is at Colorado Springs, 6,663 miles; New York, 6,883; Boston, 7,997; Chicago, 7,007; St. Louis, 7,011; San Francisco, 6,863. These places all show a greater amount of wind movement than Colorado Springs, while, on the other hand, in the following places the wind movement is somewhat less: At St. Paul it is 5,156 miles; San Antonio, 5,301; San Diego, 4,105; Thomasville, 4,225; Denver, 4,980, and Pueblo, 5,438. This average annual monthly movement of the wind at Colorado Springs is largely augmented by the springs gales, the autumn and early winter being much less windy.

The hourly wind velocity at Colorado Springs during the autumn is nine miles per hour, being only slightly greater than that of the summer season, and quite a little less than that of the winter and spring.

The number of cloudy days of the entire year is very small, averaging but 57 as against 129 in the Adirondacks, 106 at Asheville, 97 at Thomasville, 92 at San Antonio, and 73 at Santa Barbara. In the principal cities of the Union—Boston, New York, Chicago, St. Louis, and San Francisco—the number of cloudy days ranges from 88 at San Francisco to 117 at Chicago. Of the 57 cloudy days which occur through the year at Colorado Springs the fewest are seen during the autumn, averaging less than half the number in the summer and winter and one-third of the number during the spring, which is the cloudiest season. The annual average rain and melted snow fall is 14.5 inches, as contrasted with 39 in the Adirondacks, 45 at Asheville, 48 at Aiken, 51 at Thomasville, 30.5 at San Antonio, and 18 at Santa Barbara. In autumn the precipitation is not more than two inches.

The annual average relative humidity of Colorado Springs is 50 per cent., being 19 per cent. less than Asheville, 15 per cent. less than Thomasville, 18 per cent. less than San Antonio, and 23 per cent. less than Santa Barbara. In the autumn it is about 4 per cent. higher than in the winter and summer, and 8 per cent. higher than during the spring. This is because of the diminished precipitation; a little more moisture being retained in the air.

The annual average absolute humidity of Colorado Springs is 1.48 as against 3.24 for Asheville, 4.86 for Thomasville, 5.26 for San Antonio, and 4.20 for Santa Barbara. In the autumn the absolute humidity in Colorado Springs is 2.05 which is very low, though slightly in excess of the annual average.

The average temperature (Fahr.) for autumn of Colorado Springs is 48°, contrasted with 43° in the Adirondacks, 53° at Asheville, 61° at Aiken, 62° at Santa Barbara, and 34° at Davos-Platz.

The average night temperature of Colorado Springs for the autumn is 34°, being about the same as that of the spring; while in summer it rises to 51° and in winter drops to 17° F., owing to the cold but still night.

Colorado Springs has a complete system of sewerage, electric lights, and electric street cars. The water supply is brought in pipes from the mountains and is abundant and pure. The wide, level streets are shaded by trees. There are excellent stores, six banks, three up-to-date hospitals, and several first-class boarding houses and hotels. The National Tuberculosis Sanatorium of the Modern Woodmen of America is located nine miles north of the town. There are several theaters; the new Burns theater being a model in architecture, heating, and ventilation. The Antlers, recently rebuilt, is one of the most complete hotels in the West; it is fireproof and stands in a beautiful park. A fine social club house and two country clubs are adjacent. The churches are numerous and well served. The residences are detached, with gardens and trees around them, and are for the most part pleasing in their architecture. The general air and resources of the city suggest the best type of the Eastern States.

Denver.—See the separate article under this title.

Glenwood Springs—elevation 5,200, population 1,500—lies on the western slope of the great continental Divide, and is situated in a valley at the junction of the Grand and Roaring Fork rivers. The Denver and Rio Grande and the Colorado Midland railways pass through the town on their way from Denver to Salt Lake and the Pacific coast. Here is the far-

famed Yampa hot spring, from which flows each minute 2,000 gallons of water at a temperature of 134° F. This water is rich in salts, and sulphureted hydrogen gas is freely given off from its surface. The arrangements for bathing are of the most complete and modern description. There is an open swimming pool 700 feet in length and 100 feet in width, in which a hot salt bath can be thoroughly enjoyed. On one side of this pool is a beautiful bathhouse containing baths of all kinds; on the other are sulphurous vapor caves which are most comfortably fitted up. The baths of Glenwood are justly celebrated for their efficacy in the treatment of various diseases, especially gout, rheumatism, syphilis, and certain renal and hepatic affections. Its climate is soothing and restful and of great service in irritable nervous disorders.

Climatic Conditions at Glenwood Springs.

| | |
|---|---|
| Monthly mean temperature (Fahr.)— | |
| Winter | 27° |
| Spring | 50 |
| Summer | 69 |
| Autumn | 47 |
| Year | 48 |
| Rainfall (total, inches) | |
| Winter | 4.90 |
| Spring | 3.04 |
| Summer | 3.80 |
| Autumn | 4.22 |
| Year | 15.96 |
| Monthly mean temperature for January (two years) | 22° |
| Monthly mean temperature for July (two years) | 72° |
| Mean yearly minimum (three years) | 5° |
| Mean yearly maximum (three years) | 100° |

Therapeutic Use of Colorado.—What has been written about the use of high stations in the Alps applies to Colorado with certain modifications. The latitude of Colorado is much lower than that of the Alps, that of Colorado Springs being about the same as that of Naples. It is therefore much warmer, and also, because of its situation in the interior of the continent, much drier; moreover, it enjoys the climate of the high plateau as well as that of the mountain. This increases the dryness, the length of sunshine, and also the windiness of the climate. If the reader will turn to the description of Colorado Springs, he will understand how this health station combines the features of a plateau and a mountain station in a remarkable degree. The other places mentioned in this article, except Denver and Pueblo, lie more in the mountains, and receive more shelter but less sunshine, and are less under the influence of the air of the plains. When Colorado was first visited as a health resort, the idea was that it was better to place stations, particularly for consumptives, in the more sheltered resorts. For instance, Manitou and Cañon City were greatly used, and Colorado Springs very little; but the experience of the patients and of the doctors brought about a change in this respect, and, in spite of the accommodations being inferior at that time, patients frequented Colorado Springs in large numbers to the neglect of the sheltered resorts. At the present time, and indeed for some years past, the accommodations and resources for invalids have been excellent at Colorado Springs, and far better than in any other resort in the Rocky Mountain region. The wisdom of this change of base has been proved by the local experience, and is further corroborated by the successful use of open-air treatment in England and elsewhere, where the exposure to wind and stormy weather is much greater than in Colorado Springs. At the same time, the more sheltered spots are of greater service to a few of the cases. While, in comparing Colorado Springs with the Alpine resorts, we find that it excels them in the amount of sunshine and dryness, and because the climate is less harsh, we must at the same time admit that it falls behind them in that there is more wind and dust. One of the most prominent advantages that Colorado Springs enjoys—an advantage which is also shared in a lesser degree by the other Colorado resorts—is that the consumptive patient can continue under the influence of the climate all the year round, there being no falling and melting snow periods as in the Alps. To this the writer attaches great importance, because he does not believe that in seriously affected cases a residence of a few months is sufficient to insure permanent results. Further, when the consumptive is able to move about and take exercise under certain stages and conditions of the disease, he has a wide area over which he can pass; he can ride and drive, play golf, and vary his amusements. Also, at Colorado Springs, at least, he can have the advantage of literary and musical circles, and all kinds of educational and religious institutions, and find reasonable social distractions. Those also in whom the disease is arrested, but for whom it is inexpedient that they should return to their former home, or who do not desire to do so, can find opportunities for work or investment of money. The gold mining industry of the Cripple Creek district has added to the wealth and prosperity of the city, and to the business opportunities of all kinds, but has not brought any of the objectionable features of the mining camp. Besides the resources of the town, there are beautiful environs in which patients can live or to which they can resort by day.

It is often urged that for a consumptive who, of necessity or by choice, returns to his home, it is far better that he be treated in the same climate. There are undoubtedly many cases, particularly those in an early stage, in which this can be done, or must be tried; but the objection which is often made, viz., that the patient in whom the disease is arrested in a different climate, especially that of an altitude, is unable to return with safety to his home climate, does not hold. The writer in his visits to England and the Atlantic seaboard of America frequently has the pleasure of meeting old patients who have recovered in Colorado, and who are continuing in good health in their former homes. It is chiefly a question of care, especially in the first months of their return, during the period of re-acclimatization. As Sir Herman Weber and other writers of eminence have said, a patient cured in a high altitude is just as much cured as one cured elsewhere, and if a patient's condition is such as to justify his return home, provided he has acquired the hygienic education that he should receive from his physician, he can do so without fear. Of course, in sending a patient far from home, his pecuniary, domestic, and social circumstances have to be very carefully investigated and considered before such a step is taken. Nostalgia is the curse of many patients, though it is surprisingly less under the sunny and stimulating influence of a high altitude than in resorts where cloudy weather and sedative influences dominate.

The journey to Colorado, owing to the distance, is usually expensive, and the cost of living ranges about twenty-five per cent. higher than in most of the cities at sea level, but is very little if any greater than in the generality of health-resorts. Fair accommodations can be secured at a dollar a day, but for the well-to-do they would range from one and one-half to two and one-half per day. This applies to boarding-houses, which are both numerous and of all qualities. The best hotels charge from three to five dollars a day, somewhat lower rates being secured by the week.

The writer believes, and statistics confirm the belief, that in properly selected cases the arrest which is brought about in an altitude is more rapid and more lasting than that which has been procured in low places, this being probably mainly due to the fact that the changes in the blood quickly remove the anemia. Open-air life is possible and agreeable for the whole twenty-four hours throughout the year, except during occasionally stormy spells, many patients sleeping out

upon balconies through all the seasons. The statement is undoubtedly true that for most consumptives cold is better than heat; therefore the majority of consumptives improve more in the cool air of Colorado than in the warm air of New Mexico and Arizona. However, fibroid patients, in whom the circulation is feeble, and catarrhal individuals, to whom the variations of weather are dangerous, improve more surely during the winter in the warmer climates of New Mexico and Arizona, although in the summer time the cool, temperate weather of Colorado suits them better than the extreme heat of Arizona and New Mexico.

S. Edwin Solly.
Edward O. Otis.

**Coloring Matters, Animal.**—See *Pigments, Animal.*

**Colostrum** is the fluid which is secreted in the mammary glands of all mammals just before and immediately after childbirth and furnishes nourishment for the new-born. This fluid is the forerunner of the true milk and differs from it in many of its characteristics. It is secreted in women for about three days, gradually being transformed into milk upon the increased action of the glands. It often appears in the breasts during the first three months of pregnancy and may constitute one of the signs of that condition. It also has been found in small quantitites in the breasts of virgins during the menstrual period and under the stress of sexual excitement.

In appearance, colostrum is a thin, cloudy white fluid containing yellowish streaks. It has an alkaline reaction, though in some cases may be normally acid, a specific gravity from 1.040–1.060, which is slightly higher than the specific gravity of milk, and is somewhat richer in solids. The yellowish color is due to the presence of a pigment, which is soluble in ether and according to Kühne resembles in certain respects the coloring matter found in the cells of the corpus luteum. It is simpler in composition than milk and is made up of a transudate which coagulates on boiling, unlike milk, due to the greater quantity of lactalbumin and lactoglobulin it contains. In this transudate are suspended the colostrum corpuscles, the whole forming an imperfect or irregular emulsion—another property in which it is unlike milk, which is a perfect emulsion. Under the microscope the colostrum corpuscles are seen to be oval or stellate granular cells 0.001–0.025 millimeter in diameter, having an ameboid movement, and containing from one to three nuclei which stain with ammonia carmine. In the corpuscles are found fat globules, the fat contents of colostrum. Two theories exist as to the origin of these corpuscles. By some they are considered to be a fatty degeneration of the epithelial cells of the mammary glands; while others class them as leucocytes, mast cells which have gathered up the fat-globules.

As compared with milk, colostrum differs not only, as before stated, in its coagulating power on boiling, its formation of an irregular or imperfect emulsion, and its higher specific gravity, but also in the increased amount of solids it contains due to the greater quantity of fat, of sugar, and, as recent experiments have shown, of albumin than milk. Its fat constituent has a higher melting-point and a higher iodine equivalent than the fat of milk and contains cholesterin and lecithin in greater amount, the former supposed to give to colostrum its laxative property. It is however poorer in fatty acids than milk. If after birth the young are not fed from the breast, the true milk becomes gradually less in amount until just before its disappearance it again reverts to colostrum.

The milk taken from the udder of a cow at the beginning of each milking is sometimes called colostrum due to its resemblance to that fluid. The true colostrum, that secreted for a day or two after calving is usually called beestings.

According to Koenig[1] the average composition of colostrum in parts per 1,000 is as follows: Water, 746.7; solids, 253.3, consisting of casein 40.4, albumin and globulin 136, fat 35.9, sugar 26.7, and salts 15.6.

Until very recently no great importance had been attached to the nutritional values of colostrum, its chief function having been held to be its laxative effect on the intestines of the new-born infant thereby cleansing the bowels of meconium. This property was attributed to the colostrum fat. A new-born babe was not supposed to need much nourishment until the milk had appeared in the maternal breasts by which time the infant was judged to be in condition to digest the true milk. This theory has been largely overthrown by recent experiments. Langstein, Rott, and Edelstein[2] in a valuable paper on the nutritional values of colostrum, have shown by tests and analyses that human colostrum is really a highly concentrated food possessing great energy values which are attributed, not to the increased amount of fat, but to the increased albumin content of colostrum. It has been demonstrated that in dry colostrum, 9 per cent. is albumin. Experiments also show that colostrum values vary in different women and can be practically divided into two groups ranging from 1,500 to 500 calories per liter. In the first group the caloric values are high, usually highest about seven hours after delivery, and the colostrum is thick, creamy, and yellowish in appearance. In the second group the caloric values are much lower and the fluid becomes thin, bluish, and water soon after birth. The caloric values increase immediately after birth reaching almost double the values of the true milk, gradually decreasing until in about five days the values equal that of the permanent milk—650 to 700 calories per liter—which it practically becomes. The authors above mentiond state that the caloric values range from 5.178 per cent. at the birth to 4.909 per cent. one and one-half hours after birth, gradually dropping to 3.816 per cent. in forty-four hours. This decrease is brought about by a lessening in the casein and albumin contents, which they proved are modified when colostrum is allowed to stand for a length of time, an average of several days. As a result of their experiments they have shown that the energy requirements of the new-born infant, instead of being low, are, on the contrary, very high and that nature to meet this demand has supplied in colostrum a concentrated albumin milk giving in small amounts high energy values. They agree with Heubner and L. F. Myer that the loss of weight sustained in the first days of infant life is due to the concentrated colostrum feeding which Langstein calls a dry food, almost too dry, and that the gain in weight during the second week is produced by the increased water supply furnished by the permanent milk. Langstein also points out that the "old nurse" idea of feeding new babies with plenty of water was really founded on a scientific basis, although not realized.

By these experiments it has been further shown that the old theory of the fat contents giving to colostrum its laxative property must now give way to the knowledge that it is the great amount of albumin which furnishes this function to colostrum and further that colostrum is indeed a highly concentrated albumin food aptly supplied by nature to meet all the demands of growth in the new-born babe.

E. L. Jefferis.

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1. Hammarsten: A Text-book of Physiological Chemistry, 1911.
2. L. Langstein, F. Rott, und F. Edelstein: Der Nährwert des Colostrums, Zeitschrift für Kinderheilkunde, vol. vii., 1913.

**Colot** or **Collot.**—The name of a family of lithotomists, who for a period of more than one hundred and fifty years were almost the only surgeons in

France who knew how to operate according to the suprapubic method. Laurent Colot, the first of the name, practised at Tresnel, in the Champagne district, during the first half of the sixteenth century, and was appointed lithotomist at Hôtel-Dieu, Paris, by Henry II in 1556. He was taught the technique of the operation by Octavien de Ville, who in turn had learned it from Mariano Santo, of Barletta, Italy, to whom is due the credit of having been the first to publish an account of this procedure (in "Libellus aureus de lapide vesicæ per incisionem extrahendo," Venice, 1543). Laurent communicated the secret to one of his sons, who was in due course of time appointed his father's successor at Hôtel-Dieu; and so the knowledge of the suprapubic method of operating for stone in the bladder was kept entirely in the family, being handed down from father to son until the early part of the eighteenth century, the position of lithotomist at Hôtel-Dieu being given to each descendant in turn. The last incumbent was François Colot, who died on June 25, 1706. He acquired great eminence as a lithotomist and also as a general surgeon, and his professional brethren held him in very high esteem. He abandoned all attempt at secrecy and gave those who desired to learn his method of operating every facility for witnessing his work. The following treatise was published several years after his death: "Traité de l'opération de la taille, avec des observations sur la formation de la pierre, etc.," Paris, 1727.

A. H. B.

**Coltsfoot.**—See *Tussilago.*

**Coltstail.**—See *Erigeron.*

**Columbia Springs.**—Columbia County, New York.

Post-office.—Stottville. Hotel.

Access.—Via New York Central and Hudson River Railroad, or by steamer on the Hudson River to Hudson, 115 miles north of New York and twenty-seven miles south of Albany; thence four miles northeast by Albany and Hudson electric cars to Stottville.

This is a very pleasant, quiet resort, where salubrious air and charming rural scenery may be enjoyed. The springs are four in number. An analysis by Professor Atwood shows the following contents:

One United States Gallon Contains:

| Solids. | Grains. |
|---|---|
| Calcium carbonate | 21.79 |
| Sodium hyposulphite | 8.15 |
| Calcium sulphate | 64.64 |
| Sodium phosphate | 2.14 |
| Sodium chloride | 84.72 |
| Potassium chloride | 1.19 |
| Magnesium chloride | 31.43 |
| Iron sesquichloride | 3.42 |
| Loss | 0.82 |
| Total | 218.30 |

Sulphureted hydrogen gas, 4.49 cubic inches.

This analysis shows a very valuable saline-sulphur water, with a considerable proportion of iron. The water is especially efficacious in the treatment of rheumatism; of liver, kidney, stomach, and blood disorders; and of general debility. It is used for both drinking and bathing. The Crystal Rock Spring water for drinking purposes is considered remarkable for its purity.

Emma E. Walker.

**Columbo.**—See *Calumba.*

**Coma.**—This term (from κῶμα, a deep sleep) denotes a condition of profound unconsciousness in which the higher cerebral functions are in abeyance.

According to the best of our knowledge, the coördination of impressions from within and from without, by means of which we are made aware of what is going on, both in our own bodies and in the external world, is effected through the cells of the brain cortex. This awareness, or capability of appreciating impressions coming to the brain, constitutes the state of being conscious. If now, the function of the cortical cells is by any means interfered with or suspended, there is more or less clouding of consciousness, varying through the degrees of somnolence, sopor, and, stupor to coma, the most profound degree of unconsciousness. The nerve cells, subserving the highest functions of the organism, are necessarily of delicate organization and extremely sensitive to changes in the quantity and quality of the fluids in which they are bathed, hence variations in the blood supply and the presence in the circulation of poisons, either endogenous or exogenous, cannot but affect their function.

On these grounds we can probably explain the sudden loss of consciousness, following injury to the head or hemorrhage into the brain, and its more gradual disturbance as a result of brain disease or of the presence of poisons. To constitute coma, the loss of consciousness must be both profound and of some duration, differing in the latter respect from syncope or fainting which is as a rule a temporary condition.

In coma, sensation is absent and all reaction, conscious and unconscious, is suspended. The muscles are as a rule relaxed, their tonus being lost, though in certain conditions there may be muscular rigidity instead of flaccidity. The reflexes are absent, the pupils do not react to light and may be narrow or wide, even or uneven, dilating as a rule, however, when a fatal issue is about to ensue. The conjunctiva is insensible, the eyes are often half open. The patient is unable to swallow, liquids introduced into the mouth flowing out again. The respiration may remain rhythmic, but is often irregular, assuming at times the Cheyne-Stokes type, and in profound coma it is accompanied by a flapping of the palate and of the cheeks—causing stertor—and by a rattling in the air passages due to inability to get rid of the secretion in the trachea and bronchi (the "death rattle"). The pulse may be slow at the start, but is apt to be rapid and irregular at the last. The sphincter ani is relaxed and involuntary discharge of urine and feces is apt to occur.

Since coma is not a disease but a symptom, the important thing in any given case is, to determine its underlying cause, for upon the correct estimation of this all treatment must depend. Reviewing the alleged causes of coma and the conditions with which it has been found associated, we have to consider: Injuries to the head, cerebral hemorrhage, embolism and thrombosis, meningitis and encephalitis, abscess, tumor and syphilis of the brain, general paresis, epilepsy, the apoplectiform attacks occurring in arteriosclerosis (Adams-Stokes disease), febrile-toxic conditions in the acute infectious diseases, as in typhoid fever, sepsis, the other eruptive fevers and malaria, insolation, extreme muscular exhaustion, poisons arising from within the body, as from the gastrointestinal tract and in the course of nephritis (uremia), diabetes, and disease of the liver, poisons introduced from without as by overdoses of alcohol, opium, chloral, belladonna, hyoscyamus, or in poisoning by lead or by poisonous gases, and hysteria. In the presence of a case of coma, we have first to consider whether it is due to injury or disease of the brain itself, whether it is a manifestation of some more general disease, or whether it is the result of some poison of external origin. Should each of these be in turn excluded, we must then consider the possibility of its hysterical origin. The history of the case might at once make clear the cause, but unfortunately we are frequently confronted with patients,

about whose past we can learn nothing—as in people picked up unconscious on the street. Inspection of the head may disclose evidence of injury, but this is not necessarily conclusive, since in a sudden seizure the patient often falls and hurts himself. Nevertheless fracture of the skull if made out, calls for proper surgical treatment. In deciding as to the presence of brain disease, focal symptoms are of the greatest importance, and since coma is a relative term, disturbance of consciousness not being always equally profound, close examination may bring out the presence of paralysis, or local spasm may occur.

In apoplexy, it will often be noticed that the face is drawn to one side, the eyes or tongue deviate, or while the limbs on both sides are powerless, on one side they are more completely devoid of tonus, when raised and released, falling immediately to the bed, while those on the other side sink slowly down.

Coma quite frequently follows, or is associated with convulsions, which when general are hardly diagnostic. When partial and localized, however, they point to brain lesion. In meningitis, though the unconsciousness is deep, rigidity of the neck and Kernig's sign may persist and the decubitus of the patient is often characteristic. When there is disease or injury at the base of the brain, the cranial nerves are often involved with characteristic paralysis.

In the absence of any evidence of head injury and of localizing symptoms we must seek other causative factors.

A high body temperature and association of the coma with convulsions especially in a child, would justify the suspicion that one of the acute infectious diseases was beginning. Vomiting and other evidence of gastrointestinal irritation would point to the digestive tract. Extreme heat of the weather or knowledge that the patient had been working in a very hot place, especially if the hyperpyrexia was extreme, would indicate heat-fever. Malaria might be suspected if the patient had been living in a locality in which this disease was prevalent, and examination of the blood for plasmodia would give evidence for or against this disease. Waxy pallor of the complexion, ascites or anasarca, and the presence of albumin and casts in the urine would suggest that the coma was uremic, but it is to be remembered that albumin is not infrequently present in the urine after an apoplectic stroke, or even following an epileptic convulsion. Diabetic coma would be thought of, if the urine contained any considerable amount of sugar and if the breath had a peculiar sweetish fruity odor, though again moderate glycosuria is not infrequent in disease involving the medulla and some of the structures about the base of the brain. Coma from liver disease is altogether exceptional, but its possibility might be remembered in the presence of signs of serious disease of this organ. Evidence as to the habitual use by the patient of alcohol, opium, or other drug, or knowledge that something of the kind had been taken, either medicinally, or with suicidal intent, would point out the cause of the unconsciousness. Lead might show itself by the black line at the base of the teeth, while gas poisoning would be suggested by the surroundings under which the victim had been found, possibly by the odor, and lastly by the characteristic blood spectrum.

In order, however, to treat the condition intelligently with a prospect of success it is necessary to refer coma, not only to a certain class of causes, but to its specific etiological factor. In brain disease much depends upon whether the coma has come on gradually or suddenly and of course upon the symptoms, if any, which have preceded it. In apoplexy we have to decide whether we have to do with hemorrhage or embolism. The subjects of hemorrhage are usually of middle or advanced age, or are afflicted with arterial disease through syphilis or some other cause. There is often evidence of increased arterial tension and nephritis may be present. The face is apt to be congested, the respiration stertorous and the pulse slow and full, while the coma is deep. The victims of embolism are, on the contrary, more usually young and present evidence of active endocarditis, or phlebitis, or have acute rheumatism, some inflammatory trouble, or infectious disease. They are usually pale, the pulse is small and the tension low. In hemorrhage the irritative symptoms are more common, the pupils are more apt to be uneven, the eyes to deviate. The temperature at the start may be subnormal, rising later several degrees, and there may be some difference between the surface temperatures upon the two sides, that of the paralyzed limb tending to be a little higher with perhaps slight edema or local cyanosis. There is slight leucocytosis and in case the blood has broken through into the ventricular cavities, altered blood may be found in the fluid drawn off by lumbar puncture. These last symptoms are of course wanting in embolism but in it unilateral spasms are said to be more frequent than in hemorrhage. In thrombosis there have usually been some premonitory symptoms such as headache, vertigo, numbness, or local paresis and the patient is afflicted with some vascular disease, syphilis in the young, arteriosclerosis in the old, some abnormal blood state, or an infectious disease. The unconsciousness comes on gradually and is not very deep. General convulsions are rare, local spasms more common. In meningitis and encephalitis the fever and the local signs already mentioned, with the results of the examination of the cerebrospinal fluid should make the cause clear. Brain abscess might be suspected if we can find some starting point for the infection, as from the ear. Tumor will as a rule have manifested itself by the signs of headache, vomiting, optic neuritis and possibly by focal symptoms, the use of the ophthalmoscope often helping us to clear up both this and the immediately preceding conditions. Coma is not so infrequent in syphilis of the brain. It may come on comparatively suddenly and in the absence of knowledge as to the patient's past may be hard to diagnose, though the examination of the spinal fluid with the Wassermann procedure applied to it and to the blood has now considerably simplified the task. In general paresis, epileptiform and apoplectiform seizures in which coma may be a feature are very frequent. Their true basis may be made evident by local character of the spasm, if present, by the inequality of the pupils, their failure to react to light, the loss or exaggeration of knee jerk, and when the patient has regained consciousness by the incoordination of movements, and the characteristic stumbling speech. At the height of the coma a positive diagnosis may be impossible, though an increased number of cells in the spinal fluid (pleocytosis), a positive reaction to the Wassermann and to the Noguchi tests, with the Nonne-Apelt phase 1, would indicate paresis.

In epilepsy coma often succeeds the convulsive stage. Here the history of previous attacks, a fresh wound or an old scar on the tongue, a bloody foam about the lips, and the absence of other ascertainable cause may furnish the key to the situation. In persons in late middle life and in old age, with arteriosclerosis and myocardial disease, both epileptiform and apoplectiform attacks occur and of such attacks coma may form a stage. One class of these attacks is due to interference with the blood supply to the brain, the other to disturbance in the innervation of the heart muscle through degeneration of the atrioventricular bundle of His. The latter class forms the Adams-Stokes symptom-complex of bradycardia with convulsions and coma; the former class simulates closely true epilepsy. In the absence of history of attacks in earlier life and in the presence of degeneration of the heart muscle and of the arteries, we find our diagnostic criteria. In these cases, however,

uremia may also be a factor as there is frequently an accompanying interstitial nephritis.

As a symptom in acute infectious diseases, coma will rarely give rise to diagnostic difficulties in adults. In children when it comes on together with convulsions and elevated body temperature, it may be impossible to say at once just what is impending. A very high temperature, with rapid pulse and flushed face with great reddening of the throat would suggest scarlet fever, which of all the eruptive fevers most frequently is ushered in by convulsions and coma. Catarrhal symptoms and Koplik's spots would indicate measles. The cerebral disturbance tends to disappear when the eruption comes out, while in meningitis it would persist. The rarer causes of coma have been sufficiently indicated above. The most important conditions remaining to be discussed are uremic and diabetic comas and poisoning by alcohol, opium, and other narcotics.

As to what is the active agent in uremia, we have no exact knowledge, further than it is generally believed to be due to the failure on the part of the organism to get rid of some poisonous substance or substances, whose retention causes the symptoms. A discussion of this question will be found under the appropriate heading. While uremic coma is, as a rule, preceded by headache, nausea, and some of the general signs of uremia, it may burst upon the patient with suddenness and may last for hours or days, being often interrupted by convulsions which closely resemble those of true epilepsy. The general symptoms indicating nephritis have already been indicated. The coma of uremia may closely simulate that of cerebral hemorrhage. In fact this latter accident is not infrequent with the high blood pressure and diseased arteries of nephritis and may be immediately determined by the convulsions of the uremic condition. In uremic coma the temperature may or may not be elevated, but is apt to be high if there are many convulsions. The pupils are not characteristic. There may be muscular rigidity or local spasm but contrary to the rule in organic brain disease, these do not constantly affect the same muscle groups but vary from time to time. The breath may have an offensive and characteristic odor, the urine if it can be obtained, may show albumin and casts, though there are cases in which these cannot be found, at least on one examination. The eye grounds may show albuminuric retinitis.

Diabetic coma is now generally regarded as due to an acid intoxication, $\beta$-oxybutyric acid retention being considered the chief factor. It may come on suddenly or may be preceded by nausea and vomiting, headache, delirium, and specially by severe dyspnea "air hunger," the respirations being particularly full and deep. The pulse and temperature present nothing characteristic, there is apt to be a sweetish fruity odor to the breath, and the urine is loaded with sugar.

The imbibition at one time of a large quantity of spirits may cause rapid and fatal coma. As a rule, however, the coma of alcoholism is not so profound, the patient can be at least partially aroused and will then be grumbling and quarrelsome. His face is, as a rule, flushed and often presents the rosacea so common in chronic drinkers. The pulse is full and strong except near the end in a fatal case, the respiration may be stertorous, and there may be muscular twitchings, less frequently convulsions. The breath may smell of alcohol, but more frequently has the disagreeable sour odor so common in drinkers. As alcoholics often have multiple neuritis, there may be paralysis of peripheral distribution, with great muscular tenderness.

In opium poisoning, the pupils are reduced to pin points, the respiration is greatly slowed, perhaps to as low as four to six a minute. The pulse is slow except near the end in a fatal case. The capillaries of the face are dilated. Coma from belladonna is usually preceded by convulsions and delirium. The skin is hot and may show a scarlet erythema. The pulse is rapid, the respiration at the start is deep and slow, and the pupils are widely dilated. Among the most difficult cases to estimate are those in which morphine and atropine have been administered together with criminal intent. In poisoning by chloral a subnormal lowering of the temperature with complete muscular relaxation are characteristic points.

While hysterical clouding of consciousness in very common, infrequently does it reach the grade of coma. It takes rather the form of profound sleep from which the patient cannot be awakened. There is seldom complete failure of the pupils to react to light and lifting the lids is apt to meet with resistance. Urine and feces are rarely discharged involuntarily, neither is there as a rule disturbance of temperature, though hysterical fever has been described. The failure to discover any symptoms of organic disease after careful search, should put us on the right track. It has been claimed that coma can be feigned, but considering all of its symptoms it would seem almost impossible for a closely watched patient to carry out the deception very long. Bárány's method of eliciting nystagmus by cold water irrigation of the ear has recently been suggested as a means of determining whether a patient is really unconscious or not, the reaction failing in unconscious persons.

In a person picked up unconscious—that bane of the ambulance surgeon—it is most important to determine what is the cause of his unconsciousness. This may be impossible at the time. It is to be remembered that several causes may combine to produce coma. For instance an alcoholic may have nephritis or diabetes, he may take opium, he is quite liable to have a cerebral hemorrhage, and he can fall and fracture his skull. The mere odor of alcohol about him is not conclusive, for if a man falls unconscious the first move of some benevolent bystander, may be to pour whiskey down his throat. As between opium poisoning and apoplexy, it must be remembered that hemorrhage at the base of the brain may cause pin-point pupils and slow respiration. In hemorrhage, however, there are as a rule localizing symptoms. In pontine hemorrhage the temperature may rapidly rise very high. In hemorrhage into the ventricles it is subnormal. Strong pressure over the supraorbital nerve may wake an alcoholic. It is a good rule, however, that a man who is profoundly unconscious, from whatever cause, belongs in a hospital and should not be kept at a Police Station.

The *prognosis* of coma depends entirely upon its underlying cause. It is always a serious condition though not necessarily fatal. Unfavorable indications are persistance, in spite of suitable treatment, tendency of the unconsciousness continually to grow deeper, increase in frequency of respiration or Cheyne-Stokes rhythm, rapid, weak, or irregular pulse, and growing cyanosis. Diabetic coma is very fatal. Uremic coma not necessarily so. In brain disease persistent coma is of very serious import. In poisoning all depends upon the amount of the agent ingested and upon promptitude and intelligence in treatment.

The *treatment* of coma is necessarily to be addressed to the underlying condition. In all cases, the patient should be kept clean, the bladder should be emptied by catheter, in case urine is retained, not less frequently than every eight hours, the bowels attended to, the mouth kept clean, and nutrition administered in liquid form and in small quantities at a time, by the mouth, if the patient can swallow, by the rectum if he cannot and the coma is prolonged over days. Liquid can be furnished by the introduction of saline solution into the rectum by the drop method, or under the skin. In long cases bed sores should be looked out for, and points exposed to pressure should be bathed with alcohol and tannic

acid. In cerebral hemorrhage the head should be kept high and everything done to quiet the heart and to keep the blood pressure down. Very plethoric patients may be bled. In embolism and thrombosis on the contrary the circulation may need stimulation. In brain syphilis happy results have attended the intensive administration of antisyphilitic remedies.

If it is decided that the coma is due to increased intracranial pressure as in tumor, abscess, depressed bone, or accessible hemorrhage a decompressive operation or one for elevation of the bone or removal of blood clot and securing the bleeding vessel is indicated. In some cases lumbar puncture with removal of an appropriate quantity of fluid will act very favorably. Especially would this be applicable in some kinds of meningitis and in hydrocephalus. It should be carefully avoided if there is reason to suspect a tumor of the posterior fossa. Uremic coma is treated by encouraging elimination through the skin and by the bowels with attention to the heart. In some cases bleeding with subsequent introduction into the vein of a corresponding quantity of physiological salt solution or a two per cent. solution of sodium carbonate after the method of Fischer may act very favorably. Diabetic coma is to be avoided by not cutting off too suddenly all the carbohydrates from the diet and by the routine administration of bicarbonate of sodium. Once established, it is pretty generally fatal, though free purgation and the intravenous infusion of five per cent. sodium carbonate solution have proved useful. In coma from poisoning, the stomach should be washed out and the appropriate antidotes administered. In opium poisoning the tendency to coma should be combated by stimulation to the skin, by keeping the patient moving, and by the administration of strong coffee. In all cases the heart and respiration should be watched and stimulated when necessary.

CHARLES LEWIS ALLEN.

**Coma Vigil.**—This is a condition in which, while the patient lies with open eyes apparently awake, he is really unconscious. He may follow with his eyes, the movements of those in the room. but has no appreciation of what they are doing and if he recovers he has no recollection of what occurred at this time. He is delirious and may mutter to himself. His arms may be moved in a purposive manner and he plucks at the bed clothes (carphology). There may be twitching of the tendons about the wrists (subsultus). This symptom is observed in fevers, especially in typhoid, and is of grave import. It should probably be regarded as a low form of febrile-toxic delirium. The application of systematic hydrotherapy in fevers has much reduced the frequency of this and other grave nervous symptoms.

The term coma vigil was also used by Chomel to signify a condition of "unrestful sleep with frequent periods of waking and a feeling on the part of the patient that he has not slept for a long time." It is almost exclusively applied to the first mentioned condition now.

CHARLES LEWIS ALLEN.

**Comedo.**—*Synonyms:* Blackheads, acne punctata; Ger., *Mittesser;* Fr., *Verres bleues.*

DEFINITION.—A comedo is usually defined as a collection of sebaceous matter in the excretory duct of a sebaceous gland. More correctly, the blackhead is a parakeratosis of the epidermic lining of the duct and encloses between its concentric layers and in its central portion a variable amount of sebaceous matter.

SYMPTOMATOLOGY.—Comedones or blackheads are represented by slightly prominent and elevated, but in some instances depressed and discolored, points occupying and corresponding to the external follicular orifices of the sebaceous glands. They occur especially on the face, forehead, and cheeks, but also on the temples, around and in the ears, on the neck, the back, and the chest. They have also been seen frequently on the penis, scrotum, mons veneris, and on other parts of the body supplied with fat glands. Comedones may occur singly and may be distributed in a discrete manner, or they may be closely aggregated and packed together. In some cases only a few may be present, while in others they may be so numerous that the skin has a discolored, dirty, and rough appearance. In their color, and in their size great variations may be seen. In color they may be light yellow, or brown, bluish, and even black, while in size they may occur as minute dark points—on the chin producing a dusky appearance; or, as on the nose, cheeks, or back, the individual lesion may be as large as a pinhead or even larger.

Usually single, it is not unusual to meet with a double comedo, that is, one which, while consisting of one body, yet occupies two or more ducts of separate glands. When this is the case, the dark points are grouped together, separated by narrow bridges of normal skin. Pressure does not cause extrusion of one blackhead, but of all at the same time. Another type of comedo, which has been described, is constituted of "grouped comedones" (Crocker). They occur occasionally on the trunk, but particularly on the cheeks, forming symmetrical groups of densely crowded black points. They show no tendency to inflammatory reaction and suppuration. On the temples, on the lobes of the ears, and on the chest, small, papular, whitish elevations are often seen, which on pressure yield soft, white, filiform bodies resembling vermicelli sticks. They are usually classed with comedones, but are in reality small retention cysts, the sebaceous matter being accumulated in the gland body and not implicating the duct in any way. (They should not be confounded with milia, however, as the contents of these latter cannot be squeezed out.)

When pressure is applied to a comedo, a somewhat dense, resistant, more or less globular or ovoid body emerges from the follicular canal. Its outer end is yellow to black, its body is yellowish, while the lower end is soft and white, consisting of sebaceous matter from the gland body itself. The life history of a comedo is of variable duration. It may be removed by washing or rubbing, or it may persist unchanged for a long time. Inflammation of the cutaneous tissues surrounding it may and most frequently does occur, and results in the formation of a pustular lesion —an acne pustule.

ETIOLOGY.—Puberty is accused of being the most frequent and constant cause of the comedo formation. It certainly occurs most usually at or about that age, but it is also not uncommon in younger children and even in infants. That the comedo may also develop much later and in adult life is a matter of too frequent observation to constitute a rarity. The active hair growth which takes place at puberty has been regarded as an important etiological factor, as has also a want of tonicity of the walls of the follicular canal; but in all probability the physiological rather than the anatomical conditions in the evolution of the sebaceous glands at the age of development should be considered. At any rate, it can be said that coincident with the origin of the blackheads, there are also found one or more of those defects of nutrition, or those systemic disturbances so usually present at the time of puberty, such as anemia, constipation, gastric and intestinal disturbances, errors of diet, etc. The comedo formation has also been ascribed to uncleanliness, but, except under exceptional circumstances, this condition can scarcely act as a factor. Comedones are not uncommonly, however, of artificial origin. That is to say, the external appearances characteristic of a comedo may be due to some foreign substances blocking up

the orifice of a sebaceous gland. Among such, tar may be mentioned especially, and similar conditions may be seen in workers in brass and iron factories and workshops, or in firemen, oilers, or stokers. In other words, any substance blocking up the orifice of a sebaceous gland may simulate a comedo.

Pathology and Morbid Anatomy.—A comedo has usually been considered as an accumulation of sebum in the duct of a sebaceous gland. The causes of the accumulation have been ascribed to a loss in tonicity and contractility of the walls of the ducts, and the improper fatty degeneration of the glandular cells has also been brought into the question. More lately (Unna), the development of the comedo has been attributed to a parakeratosis of the external stratum corneum and that portion of it lining the duct of the gland. The cause of this hyperplasia of the horny layer is claimed by Unna to be a minute bacillus. Later reports by Hodara, Sabouraud, Engman, Gilchrist, Fleming, and others seem to confirm Unna's claim as to the causative influence of this microbacillus. For further information see article on *Acne*. Kaposi, in view of Biesiadecki's investigations, had also long before claimed that the corneous and outer layer of a comedo was due to a hyperplasia of the epidermic lining of the duct, but he had considered the irritation from the impinging of lanugo hairs on the walls as the cause of the thickening. At any rate, a comedo cannot be regarded as simply a sebum plug, since histologically it will be found to be made up for the most part of concentric layers of horny epidermis surrounding a central cone of sebum, lanugo hairs, and epidermic scales. At times the acarus or demodex folliculorum may be present, but it is not of any particular consequence in human beings.

The color of the outer end of a comedo is generally ascribed to dust, particles of dirt, etc. Unna has

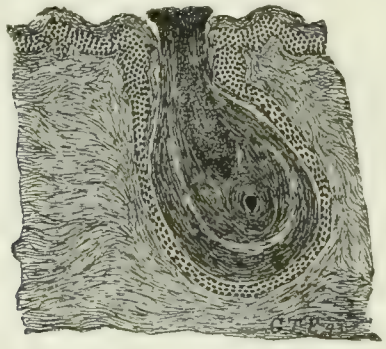

Fig. 1511—Section of a Comedo from the Back. (Original.)

claimed that it was due to ultramarine normally present in the secretions and to a darkening of the horny plug consequent upon exposure to the air. Owing to the inconsequence of the subject, definite or corroborative investigations have not been made.

The double comedo does not differ in origin from the ordinary or single lesion. The fact, however, that it communicates with a single cavity has been shown to be due to pressure atrophy. The plugging of two contiguous sebaceous glands, each with a comedo, does not cause cessation of glandular secretion. The resulting accumulation leads to mutual distention, pressure, absorption of intervening tissue, and ultimately to formation of a single cavity.

The pathological importance of a comedo resides in its intimate relationship to acne. It very usually constitutes the point of origin of a perifolliculitis and a folliculitis, or, in other words, of an acne pustule.

Diagnosis.—There should be no difficulty in recognizing comedones. Their localization, their situation in the follicular orifices, their color, and the fact that they so commonly are a focus for perifollicular inflammation and suppuration should readily obligate their recognition.

Prognosis.—The outlook in the case of comedones is always favorable, except that their presence usually leads to the development of an acne. The process is one amenable to treatment, though complete cessation in their development is difficult of attainment. In some individuals, the period during which they appear is of short duration, in others the predisposition may exist during life.

Treatment.—Particular importance in all cases of comedones should be given to the systemic health. Investigation should be made for any and all etiological factors which may be in existence, and these, whatever they may be, should be removed. Anemia, gastric or intestinal or other derangements, should be corrected, and the same attention to the general and functional health should be given as would be done in a full-fledged case of acne. The diet should be regulated. Sweets, candies, oatmeal, cheese, nuts, rich entrées, etc., should be expressly forbidden, and the regimen be made a plain but nutritious one. Moderate outdoor exercise and attention to general hygiene is called for, as well as all other matters which may conduce to improvement of the patient's bodily conditions.

The *local treatment* is also of great importance. The comedones may be removed mechanically by means of a comedo extractor, such as are found at any instrument maker's. This, however, should be done by the physician and not entrusted to the patient, and should be followed by the application of that one or other local application ordered in the case. Scraping the surface with a sharp curette has also been recommended; but it does not remove more than the outer portion of the comedo, which then quickly reforms. The operation is likewise painful and disfiguring, and in the writer's experience demands a very submissive patient. Face massage is a means of removal advocated by advertising so-called complexion specialists. The comedones are removed, but the ultimate results are usually disastrous. The same statements may be made in regard to face steaming, as the process is not disposed of simply by removing the comedo. It is the patient and his skin who require such care and such appropriate treatment as will prevent the reformation of the comedo after its removal that is necessary. In view of what has just been stated, it may be understood that all purely local remedies are therefore only such as are aids to the general systemic treatment. An efficacious and simple remedy, which softens and removes the blackhead, is an ointment:

℞ Sodii boratis. . . . . ʒiij.
Ung. aq. rosæ. . . . . ʒi.

M. Sig.: Apply freely, and after a half to one hour wash off with soap and *cold* water.

Then apply one or the other of these lotions:

℞ Zinci sulphatis,
Potassii sulphidi,
Sulph. præcip . . . . . āā gr. xv.
Aquæ rosæ. . . . . ʒj.
M.

or

℞ Hydrarg. chlor. corros. . . . . gr. ij.
Acidi acet. dilut. . . . . ʒvj.
Aquæ rosæ,
Spts. vini. . . . . āā ʒss.
M.

or a saturated solution of salicylic acid in alcohol may be used. The latter causes a free exfoliation of the horny epidermis, and the comedones are frequently removed entirely by its means. Among

ointments, there may also be mentioned the Ungt. hydrarg. ammoniat., 5 to 10 per cent.; Ungt. resorcini, 3 to 10 per cent.; Ungt. sulphuris, 5 to 10 per cent.; etc. Soap and cold-water washings twice a day are of great value. The kind of soap is not of importance, so long as it is a neutral one and does not contain an excess of lye. However, soaps with sand or with marble dust have been recommended, as well as the tincture of green soap, and also a host of medicated soaps with which the market is to-day inundated; but when it is borne in mind that the cause of the comedo formation is the important factor requiring treatment, it can be judged that all of these are only subsidiary and not agents of any special value.

GEORGE T. ELLIOT.

**Côme, Frère.**—See *Baseilhac, Jean.*

**Comegys, Cornelius George.**—Born at Cherbourg, Kent County, Delaware, on July 23, 1816. He studied medicine at the University of Pennsylvania, in Philadelphia, and received his doctor's degree in 1848. In the following year he began the practice of his profession at Cincinnati and very soon acquired a large practice. In 1851 he went to London and Paris for clinical study. In 1852 he was chosen Professor of Anatomy in the Cincinnati College of Medicine and Surgery. After giving one course of instruction he resigned, in order to accept the Chair of the Institutes of Medicine in the new Miami Medical College. In 1857 the latter school became fused with the Medical College of Ohio; but Dr. Comegys continued to hold the same chair in the new organization until 1860, when he and several other members of the Faculty resigned. Four years later he was reelected, and the additional title of Professor of Clinical Medicine was given to him. In 1857 he became connected with the Cincinnati Hospital. He was strongly convinced of the need of a National Department of Public Health and spoke and wrote often, during the later years of his life, in advocacy of the establishment of such a Department in Washington. He died February 10, 1896.

The most important piece of literary work done by Dr. Comegys is his translation of Renouard's *Histoire de la Médecine* into English. Of the numerous short papers which he contributed to current medical literature the following deserve to receive special mention: "On the Pathology and Treatment of Phthisis," 1854; "On Cool Bathing in the Treatment of Infantile Enterocolitis," in the *Phila. Med. Times*, July, 1875; and "Treatment of Asiatic Cholera," in the *American Journal of Medicine*, 1866.

A. H. B.

**Comfrey.**—SYMPHYTUM. The root of *Symphytum officinale* L. (fam. *Boraginaceæ*). This is a coarse, rough, perennial herb of Europe, sparingly naturalized in the United States. For medicinal use the root is gathered in autumn, split longitudinally, and rapidly dried. It is then furrowed and wrinkled, with a black surface and bluish-gray section. It occurs mostly in pieces from one to four inches in length and of the thickness of a lead-pencil or less. Its texture is hard and horny; fracture, cellular; taste, mucilaginous, slightly bitter, and astringent.

Comfrey has been long in use, as a vulnerary (see *Allantoin*) and as a demulcent and "pectoral"; its constituents, besides allantoin, are similar to most others of its class: *mucilage, sugar, asparagin, tannic* and *gallic acids*, and *starch*. Dose—a decoction may be taken *ad libitum*.

The *leaves* have a similar composition and use.

HENRY H. RUSBY.

**Commensalism.**—An intimate relation between two organisms in which one is usually benefited but neither is injured. The lower animals furnish many instances of such association. The little crab, *Pinnotheres*, which lives in the oyster is an excellent example of a commensal animal. It seldom leaves the mantle chamber of its "mess-mate" and obtains food by straining microscopic organisms from the currents of water that pass in and out. Apparently the oyster is not harmed. The Remora, or Sucker Fish, which attaches itself to sharks in order to steal a ride, the barnacles growing on whales, and the little mackerel which seeks protection among the stinging tentacles of the Portugese-Man-of-War are other examples.

Instances of commensalism are not frequent among the higher animals. Many protozoans live in the alimentary canal of ruminants without apparent effect. *Entamœba coli* seems to do no harm in the intestine of man.

A. S. PEARSE.

**Complement.**—As long ago as 1887 it was recognized that normal blood possessed a certain bactericidal action but it was much later that Buchner was able to demonstrate that cell-free blood serum was able to kill microorganisms. Buchner called the substance which he recognized as an important item in the defense of the body against infection, alexin, and was able to determine certain of its properties. Thus he found that it is thermolabile, being killed under ordinary circumstances by a temperature of 55°P. in thirty minutes, although it is probable in view of later researches that the whole amount of this substance is not so destroyed. It is killed in a few hours by exposure to the direct rays of the sun. It is very resistant to cold, its activity being unaffected even by the temperature of liquid air. It is not acted upon by pepsin, by neutralization of the fluid in which it is contained, or by the removal of the gases from that fluid. The addition of salts to the fluid is able in a measure to protect the alexin against the effects of heat. If the solution be precipitated with ninety per cent. sodium sulphate solution and the precipitate dried at 70°C. and dissolved in water, the resultant solution is as active as the original serum. It was discovered later that hemolysins reacted in very much the same way and then that Buchner's alexin was really a combination of two substances which are now known as amboceptor and complement, the latter corresponding to the alexin. The amboceptor is highly specific while the complement has little or no specificity. It is possible to separate the two by means of cold since the amboceptor will unite with the cell at 0°C. while the complement remains unattached.

Up to the present time no one has been able definitely to prove that there is more than one complement. It is true that one preparation seems to act a little differently toward different cells or bacteria but the same complement seems able to be used in all of the serum reactions and the theory of the unity of the complement has been generally accepted.

Complement is a labile albumin-like substance and in all its reactions behaves as though it were an enzyme. It is gradually used up in killing bacteria and its power depends to a certain extent on the concentration of the suspension in which it is allowed to act. It is probably always present in the circulating blood and is not formed merely upon disintegration of the leucocytes. It has been objected that the same quantity of anthrax bacilli which are killed in a short time by exposure to a few drops of dog serum will kill a dog when injected into him. But if the bacilli are put into a cotton plug and exposed to the serum, those in the interior of the plug are not killed even after long exposure. So it is argued that in the body the bacteria are protected in the interstices of the tissues. The bactericidal power of the leucocytes is well known and many have argued that

the activity of a leucocytic extract is due altogether or largely to the presence of complement. A leucocyte extract however differs somewhat from complement in its action. It will not act upon the red cells of a strange species and is certainly not identical with the hemolysin of the blood serum. Its activity is independent of the salt content of the fluid and it is not destroyed at 60° but is first affected at 80°–85°. The leucocytes have been shown to yield ferments such as fibrin ferment, saponase, proteolytic ferment, amylase, and casease, and it is not difficult to believe that complement may be a leucocytic product. The digestion of fresh blood serum with pepsin resulted in obtaining a nuclein which exhibited bacteriolytic powers but which did not react in other ways like complement. The hemolytic power of a serum seems to depend somewhat on the lipoid content of that serum. All these are observations of great interest, but it must be said that the chemical nature of the complement has not yet been explained.

The source of the complement has naturally been the subject of much dispute. Organ extracts have shown the brain, muscle, and thymus to be practically inactive and the liver, kidney, pancreas, and suprarenal only slightly so. The lung, connective tissue, spleen, and lymph nodes are strongly bactericidal while extracts of the red bone marrow exhibit the strongest activity. Serum obtained from the carotid and jugular vessels shows a higher activity than that from the blood drawn from the femoral vessels. Extirpation of the spleen apparently made little difference to the animal in its ability to resist infection or in the complement content of its serum. Metchnikoff divides the complement into a macrocytase which is hemolytic and is derived from the mononuclear cells of the blood, and a microcytase which is bactericidal and is derived from the polynuclears. It is probable that under favorable conditions every cell is able to yield a certain amount of complement. From what we know at present, however, it is probable that the chief source of complement of the body is the myeloblast of the bone marrow.

RALPH G. STILLMAN.

**Complement, Deviation or Fixation of.**—The serum of an animal which has been immunized against the red cells of an animal of another species contains antibodies which have been called hemolysins. If such a serum is mixed with red cells of the same kind that have been used for immunization, hemolysis occurs, that is the red cells become dissolved. This hemolysis is the result of the combined action of two factors, the antibody or amboceptor and the complement. The complement is the active or dissolving factor while the amboceptor serves to join the red cells to the complement thus giving the latter an opportunity to work. In the absence of amboceptor the cells and the complement are unable to join and no action will take place. The cells and the amboceptor, however combine readily in the absence of complement and when so combined the cells are said to be "sensitized." The addition of complement to sensitized red cells results in hemolysis. Such a combination of cells or antigen with amboceptor and complement is called an "immune system." Complement is thermolabile, being destroyed by heating at 56° C. for thirty minutes, while amboceptor is not affected by this temperature. A serum which has been so heated and therefore deprived of complement is said to be inactivated.

Complement is a constituent of all normal sera and possesses but little specificity, so that each complement is capable of reactivating sera other than that of its own species. The ability to do this varies, but the complement of the guinea-pig is able to reactivate the sera of many species and it is therefore used widely in immune reactions. Amboceptor, it must be remembered, is highly specific. These reagents are susceptible of titration. The smallest quantity of amboceptor in the presence of which a fixed quantity of red cells will be dissolved by an excess of complement is known as an amboceptor unit. The smallest quantity of complement which in the presence of one amboceptor unit is able to cause solution of the same quantity of red cells is known as a unit of complement. If some other amboceptor with its antigen is mixed with one unit of complement and time allowed for their combination, the complement will be firmly fixed in that immune system so that when later red cells and one unit of red cell amboceptor are added there is no free complement and fixation or deviation of the complement is said to have taken place. The smallest amount of antigen which will completely fix one unit of complement so as completely to inhibit hemolysis in the hemolytic system is known as one unit of antigen.

These phenomena form the basis of the various complement deviation tests which are now employed for diagnostic purposes. Antigen representing the suspected cause of the infection is mixed with inactivated serum of the patient and fresh guinea-pig complement. The mixture is incubated and to it is later added a fixed quantity of red blood cells and their amboceptor. If there is present in the serum an antibody which has been developed against that particular antigen then the immune system will be complete, the complement will be deviated, and hemolysis will be inhibited completely. If no such amboceptor is present in the serum the complement will remain free and hemolysis occurs on completion of the hemolytic system. The actual performance of the test requires a high degree of technical skill and a very careful attention to quantitative details, but the general principle is as stated above. The value of this test as a diagnostic measure is very great, since by its aid it is possible to recognize much smaller quantities of antibody in a serum than is possible by the use of any of the direct immunity reactions such as the agglutination test.

The best-known application of this principle is, of course, in the Wassermann test for syphilis. At the time when this test was devised the cause of the disease had not been isolated and therefore an extract of syphilitic organs was used for antigen. Later it was found that extracts of various normal organs, when properly prepared, would act satisfactorily. It was recognized that in this instance the test was not, strictly speaking, a specific one and yet the results have been very satisfactory. Since the isolation of the *Spirochæta pallida* by Noguchi some operators have substituted a preparation of the spirochete for the organ-extract antigen and have claimed thereby to have obtained superior results. There are not figures available, however, to determine the value of this modification. The details of the Wassermann test for syphilis will be found in the article under that heading.

In the case of gonorrheal infections the antigen is a preparation of the gonococcus. The test is not positive in the early stages of an acute gonorrheal urethritis, but soon becomes so and remains for a long while. It is regularly positive in general gonorrheal infections, especially in gonorrheal arthritis, and has proved a valuable means of diagnosis in this condition.

Complement fixation phenomena are made use of also in the diagnosis of other infections, especially in cases where the other immunity reactions are inapplicable or unsatisfactory. In each instance the antigen employed is a preparation of the suspected infecting organism and the indicator a hemolytic system. In helminthiasis the test has been used to a slight extent with fairly good results, the antigen being prepared from the worm. A complement

fixation test has also been advocated for pregnancy in which the antigen is a preparation of the chorionic villi. The results have been very variable, however, and it will probably be superseded by other tests based on a different principle.

RALPH G. STILLMAN.

**Complementoid.**—It has been assumed that complement is composed of two portions. One is the haptophore group which has an affinity for the complementophile group of the amboceptor, the other carries the ferment and is the active or function group. The function group is the less stable of the two and so dies out of a serum before the binding group. Complement in which only the haptophore group is active, is called complementoid and it has only the ability to unite with amboceptor and therefore no power to bring about lysis of red cells or bacteria. The chief importance of complementoids is that by their presence they prevent the union of active complement with amboceptor and thus prevent hemolysis in complement deviation tests. It is possible that they are the chief cause of the so-called "anticomplementary reactions." It must be admitted however that there is no experimental evidence for the existence of complementoids and that their existence is purely an assumption and that many of the phenomena ascribed to them are explainable by other hypotheses. RALPH G. STILLMAN.

**Compositæ.**—(*The Daisy Family.*) Taken in its broad sense, as generally regarded, this is our largest family of plants, comprising more than 800 genera and more than 10,000 species, though some authorities reduce the number by separating, as distinct families, a number of our subfamilies. There is scarcely any flora of the earth where these plants are not found, or even where they are not abundant. Their economic importance is great, as ornamental plants and to some extent as foods. Among the latter are the artichokes, salsify, burdock, several plants of the thistle group, lettuce, and chicory. Starch is largely wanting in the family, its place being filled by the closely related *inulin*, and this is the important nutrient constituent. Medicinally, the family represents three classes of agents, dependent upon distinct classes of constituents. We have first, stomachics and tonics, dependent upon volatile oils and bitter substances. In some cases, as in the iron weeds (*Vernonia*), the bitter element is almost alone; in others, like Erigeron, the volatile oil is nearly devoid of bitter association. In some cases, moderate quantities of tannin are also present. Occasionally, these substances are anthelmintic, as in santonica, or insecticidal, as in the insect flowers.

The second class of remedies depend upon resins or powerful volatile oils for their counterirritant properties. Internally they are powerfully irritant, to the extent of being poisonous, like arnica, pyrethrum, or tansy.

Thirdly we have a few milky juiced plants of the suborder *Cichoriceæ*, with laxative and alterative properties, like dandelion and chicory, or even narcotic like lactucarium. A few, like absinthium, possess peculiar properties, due to special constituents. An enumeration of all the drugs of this family in domestic and aboriginal use would carry us far into the hundreds, yet the total medicinal importance of the family cannot be regarded as other than minor.

HENRY H. RUSBY.

**Compressed-air Disease.**—See *Caisson Disease*.

**Compsomyia.**—A genus of flies, family *Muscidæ*, which contains the much-dreaded larval form known as the "screw-worm," *C. macellaria*, of the warmer portions of America. The eggs of this species are deposited on various decomposing substances, but are not infrequently placed in the nostrils of human beings, particularly when there is a catarrhal condition. As many as three hundred maggots have been dislodged from the mouth of a single individual. See *Insects, parasitic.*

A. S. P.

**Conception.**—This term is used interchangeably with impregnation and fecundation by obstetricians, fertilization being the one which is commonly used by embryologists and biologists. It signifies the condition which results from fertile union between the male and female reproductive elements, with the coming of a new being into existence.

*The Elements in Conception.*—The elements in question are the ovum of the female and the spermatozoon of the male. We are referring, of course, to conception in human beings, unless it is otherwise specified. The ovum, which is the fruit of the ovary, lies when mature near the surface of the Graafian follicle embedded in the membrana granulosa. It is an opaque spherical body uniformly about one-twentieth inch in diameter. From without inward it consists of the zona pellucida or vitelline membrane, yolk, germinal vesicle, and germinal spot. The vitelline membrane is transparent and is said to be impervious, though in some of the lower animals it contains a minute opening or micropyle.

The most recent descriptions by embryologists confirm this statement which for a long time was doubted. The yolk or vitellus is a viscid granular material, as in the egg of birds, composed of protoplasm and deutoplasm, and conforms to the spherical shape of the investing vitelline membrane. The germinal vesicle is a nearly spherical body $\frac{1}{120}$ of an inch in diameter surrounded by a thin membrane. It contains linin, chromatin, and achromatin and the germinal spot, and when mature is in contact with some portion of the vitelline membrane.

The germinal spot is an opaque body $\frac{1}{3300}$ to $\frac{1}{2500}$ inch in diameter consisting of cells and granules and is located near the inner surface of the wall of the germinal vesicle. The Graafian follicle or vesicle in which the ovum is embedded contains a fluid and cellular elements derived from the membrana granulosa. It usually contains but one ovum but may contain two, three, or more.

The spermatozoa are the essential germinative elements in the viscid seminal fluid or semen, and are developed from the so-called vesicles of evolution which it contains. They are elongated flagellate cells $\frac{1}{500}$ inch in length, each one being composed of head, middle piece, tail or flagellum, and end piece. They have a wonderful power of motility which enables them to progress their own length, or $\frac{1}{800}$ inch, per second. They have great vitality and may remain active in the female genital tract two weeks or even longer. Their activity is increased by alkaline solutions and destroyed by those which are acid. When the ovum and the spermatozoon are in normal condition and are brought in contact with each other, under favorable circumstances, the result will be conception.

*Means by which Conception is Accomplished.*—The means by which conception is accomplished in the mammalia is the sexual act or coitus,* the seminal fluid being deposited in the vagina. It is not essential that it should be deposited in the

* It is interesting to note that in the osseous fish, amphibian, and some invertebrates conception or fertilization is accomplished by the application of the male generative material to the ova entirely outside the bodies of the male and the female.

Loeb's recent successful experiments in fertilizing the ova of the sea-urchin by chemical means are well known and remarkable.

Artificial impregnation of sterile women was proposed and attempted in several instances by Marion Sims but without success.

uterus and unless the os uteri is very patulous it is not so deposited.

When the walls of the vagina are brought into apposition, after coitus is concluded, more or less of this fluid is distributed upon the os.

In point of fact it is not necessary that it should be deposited within the vagina, for numerous cases have been reported in which pregnancy has occurred without penetration of the vagina during the sexual act.

This is entirely credible when we remember the vast number of spermatozoa which are present in each discharge of semen, their wonderful vitality and activity, and the essential fact that only one spermatozoon penetrates each germinal vesicle.

Should multiple pregnancy or conception occur it simply means that more than one ovum has been liberated from the Graafian follicle and projected into the tube, and that each has been penetrated by

Fig. 1512.—Ovary with Mature Graafian Follicle about ready to Burst. (After Ribemont-Dessaignes in Heissler's Text-book of Embryology, W. B. Saunders Co.)

a separate spermatozoon. When the ovum is mature or ripe it is discharged from the Graafian follicle, the membrana granulosa parting at the side or bursting at the point of greatest tension and the contents—liquor folliculi, granular matter, cells, ovum, and blood running out over the surface of the ovary.

In some cases the ovum is probably disintegrated and absorbed, but when the conditions are favorable it is caught within the folds of the fimbriated extremity of the Fallopian tube and is propelled along the lumen of the tube to the uterus, partly by the peristaltic action of the muscular fibers of the tube and partly by the ciliary action of its epithelium.

*The Period within which Conception may Occur.*—The passage of the ovum through the tube takes about seven days, its activity and vitality usually continuing for a similar period. It is now believed by most embryologists that conception takes place during these seven days. But the vitality of the spermatozoa may last as long as fourteen days or even longer, hence conception may occur within that length of time after the last coitus.

Graafian follicles may mature and cast out their ova at any time but embryologists think that the rupture of the follicle and the discharge of the ovum most frequently occur at the time of menstruation. Hence, according to this view, conception is most likely to take place within the week which follows menstruation, thus justifying the ancient and common custom of reckoning conception from the patient's last menstrual period. However this may be, physicians often find that this rule does not always hold good in practice, particularly in primiparæ, pregnancy frequently ending three or four weeks later than its estimated period.

The rate of progress of the spermatozoa does not seem to be definitely determined. Henle states that it is one inch in nine and a half minutes, while Heisler maintains that it is one inch in eight and a half minutes. If either of these statements were true and its progress were continuous and in a straight line it would traverse the entire length of the uterus and Fallopian tube in less than two hours. It is probable, however, that its progress is an interrupted one and hence it is impossible to state definitely the duration of its migration from the os uteri to its point of junction with the ovum. There is substantial agreement among embryologists that it meets the ovum in the outer third of the Fallopian tube and that within this area conception usually takes place. This affords an explanation for the great frequency of tubal pregnancies particularly in this portion of the tube.

*Normal and Abnormal Conception.*—If conception is normal and we concede that it has occurred in the outer third of the tube the ovum is propelled through the tube into the uterus by the action of the cilia of the epithelium of its mucous membrane and the peristaltic action of its muscular fiber, is there implanted upon the mucous membrane, is soon covered by a decidua, and is then ready for the development of the living being which it contains.

Abnormal conception may be tubal, ovarian, and possibly abdominal. The first of these is by far the most frequent and means that, for some reason or other, the ovum has been detained within the tube instead of moving onward to the uterus.

Conception within the ovary is exceedingly rare and until very recently was supposed to be imaginary. Bischoff is reported to have seen spermatozoa upon the ovaries of bitches and rabbits and from this fact it was supposed that they might penetrate the unruptured wall of the Graafian follicle. This supposition is unnecessary, for the ovum has been known to migrate from one ovary to the tube on the opposite side of the body, there to become impregnated. This being the case either ovarian or abdominal pregnancy would seem to be entirely possible.

A very small number of cases of well-authenticated ovarian pregnancy have been reported within the past few years, and this gives the possibility of validity to previously reported cases which had been rejected by pathological authorities.

Abdominal conception, the ovum being fertilized while lying upon the peritoneum, is still debatable though there seems to be no inherent reason why it should not be possible. Many cases have been recorded in which the fetus has developed, frequently to maturity, within the abdominal cavity, the ovum being extensively attached to the peritoneal covering of the intestine, and most gynecologists of experience have seen more or fewer of such cases. They have almost invariably, perhaps always, been explained as tubal conceptions the tube rupturing at the fifth or sixth week of pregnancy, the ovum has then formed an attachment to the peritoneum and continued its development within the abdominal cavity.

*The Immediate Phenomena of Conception.*—Conception is the moment of effective fertilization and is followed by the phenomena of pregnancy. The following description of the actual process of fertilization is essentially that of Heisler.

As the spermatozoon strikes the vitelline membrane its protoplasm swells and forms the receptive prominence through which it bores its way, its tail being absorbed by the cytoplasm of the ovum, or left outside. Its middle piece or a part of it including the end knob or centrosome enters the ovum together with the head or nucleus. The head enlarges and becomes the male pronucleus.

The male and female pronuclei approach and meet in the center of the ovum, the two *apparently* fusing to form a single segmentation nucleus or cleavage nucleus. An *actual* single membranate nucleus is not formed, but as the pronuclei approach each other the centrosome of the spermatozoon lies between them surrounded by its attraction sphere

and gives rise to the nuclear spindle, the chromatin threads of the two pronuclei lying in relation with its equator but on opposite sides to each other.

One-half of each chromatin thread goes to one pole of the spindle and the other half to the opposite pole, producing two daughter nuclei as the result of the first segmentation of the segmentation nucleus. The chromatin coming from each parent anatomically explains parental characteristics according to Hertwig and Strasburger.

*Factors which Favor or Interfere with Conception.*—Conception being a physiological act implies a normal condition of the factors which contribute to it. The ovum and the spermatozoon must both be healthy,

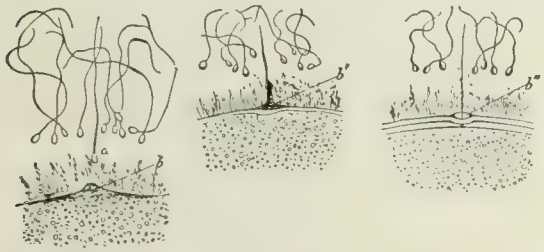

Fig. 1513.—Spermatozoa Progressing toward an Ovum. *a*, Spermatozoon approaching the central prominence (*b*) of the ovum; *b'*, spermatozoon in contact with the central prominence; *b''*, ovum penetrated by the head of the spermatozoon. (After Hertwig.)

conception will not take place if one or both are unhealthy. A healthy spermatozoon may penetrate an unhealthy ovum or an unhealthy spermatozoon a healthy ovum and conception will not occur, or if it does occur the product will be a defective being. The spermatozoa may be dead when the seminal fluid is discharged, or the ovum may be incapable of fertilization.

The organs of generation in male or female may be structurally defective and conception will not take place.

Conception is often prevented by various mechanical devices which are used by both men and women during coitus, by destroying the spermatozoa after they have been deposited in the vagina by means of douches and injections of various kinds, etc.

One reason for the comparative infrequency of conception in prostitutes may be the antagonism which spermatozoa from different individuals have for each other, and their mutual neutralization.

Conception is improbable when either the male or the female suffers from certain wasting diseases, from poisoning with various substances, from the prolonged use of the *x*-ray apparatus, and as a consequence of certain occupations. On the other hand conception is favored by all that conduces to physical well-being, by maturity of development, by physical vigor, by well-developed generative organs, etc. The desire for offspring is doubtless a factor in conception in many cases but it is insufficient if other necessary factors are wanting, as many sterile marriages will testify.

Whatever the situation may be, and whoever the individual, the fundamental requirement is that normal spermatozoa be brought in contact with normal ova; all other factors are merely contributory, for or against. Andrew F. Currier.

**Concretions and Calculi.**—Concretions and calculi are terms applied in medicine to aggregations of solid, more or less hard substances, which form in the body-tissues or fluids and act as foreign bodies. The substances composing the aggregations are usually such as are formed in the tissues and fluids normally or pathologically, and may be either organic or inorganic substances, or a mixture of both; occasionally, however, foreign matter finds its way into some part of the body and acts as a nucleus for a calculus. Crystalline, granular, or amorphous masses may be deposited in a tissue and thus cause it to asume a hardened state; or the latter condition may result from the absorption of fluid. The terms petrifaction and calcification are applied to such hardenings so long as the tissue in which the change occurs bears its normal relation to the surrounding parts; but when this relationship ceases and the hardened area acts as a foreign body, then it is proper to employ the terms concretion or calculus, whether the mass is embedded in the tissues or lies free in some cavity.

Chemically, the change most frequently results from a deposit of calcium carbonate or phosphate with perhaps in addition a small amount of magnesium salts. The process is apt to accompany or follow degeneration or death of tissue; in fact, it seems as though tissue undergoing necrobiosis has a special attraction for calcium salts. Connective tissue undergoing hyaline degeneration with accompanying calcification is often encountered in the walls of the blood-vessels, in the endocardium, in the thyroid, and in the thickened pleura, and may be found in other portions of the body. Calcification of tuberculous areas, uterine fibroids, and ovarian and other cysts is also frequent. Under exceptional conditions, and more particularly in advanced age, the process occurs in tissue in which degenerative changes are not recognizable. In rare instances calcareous infiltration is believed to be due to an absolute increase of calcium salts in the blood, such as perhaps occurs in extensive caries and in osteomalacia. This is certainly unusual, but some observations seem to support the view.

Amyloid concretions, or corpora amylacea, are small, oval, homogeneous or laminated bodies that frequently occur in the tissues of the nervous system and in the prostate. In the nervous system they are especially apt to occur in conditions of atrophy or softening. The ependyma of the ventricles, the white substance of the brain, the choroid plexus, the optic nerve, and the spinal cord are their favorite seats. They are occasionally met with in the lungs, in mucous and serous membranes, and in extravasations of blood. Amyloid bodies were formerly believed to consist of amyloid substance. While it is true that they may assume a bluish color on treatment with solution of iodine or iodine and sulphuric acid, and resemble somewhat in structure the product of progressive amyloid change, it is recognized that their formation is dependent on local changes, and it is not believed that they are similar to the product of amyloid degeneration. Redlich considers the corpora amylacea of the nervous system, which stain similarly to nuclei with hematoxylin, to be made up of the nuclei of neuroglia cells and to be a senile retrograde development of the tissue. Stroebe believes them to be composed of fragments of swollen axis cylinders, while Siegert believes them to have originated from cells. In the choroid plexus and lateral ventricles they frequently become calcified and then constitute one form of "*brain sand.*"

Biliary concretions are both frequent and of clinical importance. Europeans have found gallstones in from five to ten per cent. of all autopsies; in the East, on the contrary, they are extremely rare, only one or two cases being recorded.

The stones are usually found within the gall-bladder, less frequently in the cystic or common duct and in the alimentary tract, having passed down from the gall-bladder. The diagnosis of intrahepatic calculi is not made during life, yet such calculi are said to occur in 8.3 per cent. of the gallstone cases that come to autopsy. Noguchi reports a case where the stone was not found in the bladder or duct but in which it

was felt in the liver at operation and successfully removed. Biliary fistulæ are not uncommon, and through these abnormal communications gallstones have been known to pass to the outside of the body, into the abdominal cavity, into the stomach or intestines, into a liver abscess, into the portal vein, or into the urinary passages, and records are not rare in which they have entered the lungs. A single calculus may be present in the gall-bladder, in which case it is usually ovoid and may be quite large; or the number may be very great, 7,802 having been reported in one case. The usual number is between four and fifty, and the average size is apt to vary inversely with the number, from that of a pinhead to a cherry. When numerous they may be the size of small grains, while, on the other hand, Meckel has described a single biliary calculus fifteen centimeters long and six broad. When more than a few are present they commonly lose their ovoid shape and show signs of mutual pressure, having a polygonal form with smooth facets. All those present in the same individual commonly have the same chemical composition and present the same physical characters, but may vary considerably in size.

Chemical analysis has shown that the vast majority of biliary calculi are composed chiefly of either or both of two substances, viz., cholesterin and the calcium salt of bile pigment, known as bilirubin-calcium. Either of the two substances may be the sole constituent or they may together form the mixed varieties, with the two substances in almost any proportion. Certain materials only occasionally enter into the composiiton of gallstones or do so commonly only in very small amount: such are inorganic calcium salts, notably the carbonate, sulphate, and phosphate, small quantities of copper, traces of iron, zinc, and manganese, globules of mercury, fats, silica, uric acid, and foreign bodies. Of these latter the round worm, a portion of distoma hepaticum, a needle, and a plum stone have each been recorded as being the nucleus of a calculus. The presence of calcium salts in mixed calculi, particularly the carbonate, contributes hardness; in rare instances the concretion may be chiefly or entirely calcareous. The bile acids and other constituents of bile are found in calculi only in such traces as are explained by the absorption of this fluid in the interstices. Again, the bile pigment in combination with calcium is not always bilirubin, but frequently in part biliverdin or bilifuscin.

It may be said that in general cholesterin predominates in the larger stones, while the smaller are more apt to contain considerable bilirubin-calcium. Naunyn, in his admirable treatise on cholelithiasis, recognizes six classes of gallstones:

1. *Pure Cholesterin.*—Usually pure white or yellowish, translucent: in rare instances dark colored. Ordinarily oval or roughly spherical in form, hard, seldom exhibit facets, not stratified or only feebly so and vary in size from a cherry to a pigeon egg.

2. *Laminated Cholesterin.*—Contain ninety per cent. or more of cholesterin, the other constituents being calcium compounds of the bile colors and calcium carbonate. Are usually hard, but occasionally when dry, brittle and friable, more frequently facetted than the first variety, more or less distinctly laminated, with the layers perhaps differing in color, often with those nearer the center more crystalline in structure and those nearer the surface hardened by the presence of calcium carbonate. They resemble cholesterin stones in form and size, but are apt to be somewhat darker in color.

3. *Common Gallstones.*—These comprise the great bulk of gallstones, varying in size (pinhead to cherry), in composition, and in form and tint. Usually facetted and laminated. The soft nucleus may consist of bilirubin-calcium, or the center may consist of a cavity holding a yellowish alkaline liquid. If soft when removed they harden and shrink on drying, without developing fissures.

4. *Mixed Bilirubin-calcium.*—Usually the size of a cherry, occur in groups of three or four, and are facetted. They are twenty-five per cent. or less cholesterin, the remainder being chiefly bilirubin-calcium. They have a brown color, are seldom hard, and develop fissures when they dry.

5. *Pure Bilirubin-calcium.*—Common in cattle, rare in man. Vary in size from a grain of sand to a pea, being the stones that are sometimes observed in the intrahepatic bile ducts. The smaller ones may have a wax-like consistence, with brownish-black, rough, irregular surface, while the larger ones usually are brittle, have a smooth surface, and a gray to black color with a metallic luster. In calculi of this class bilifuscin is practically always present.

Fig. 1514.—Biliary Calculi, Facetted, of Impure Cholesterin, Removed from a Gall-bladder. (Natural size.)

6. *Rarer Forms.*—(*a*) Amorphous and incompletely crystalline cholesterin gravel: small, often resembling pearls, and always with a nucleus of different structure. (*b*) Calcareous, consisting almost entirely of calcium carbonate. (*c*) Concretions which include foreign bodies and conglomerate stones. (*d*) Casts of bile ducts. Schade divides them into three types, pure cholesterin, bilirubin-calcium, and pigment-calcium-cholesterin.

As to the source of cholesterin in bile, Austin Flint a half century ago presented the view that the separation of this constituent from the blood by the liver is a regular and important function of this organ. Whether it is increased in bile by an increase in the blood has been differently held at one time and another, the view of Naunyn that it is not so increased but is increased *in situ* from epithelial degeneration now having given way to the opinion that there is increased excretion in the bile. This latter view finds support in the presence of cholesterin in the red corpuscles and its increase in bile following their destruction. As to the cause of the separation of cholesterin from solution; Exner and Heyrovsky conclude that the bile acids hold it in solution and

that their destruction by the growth of bacteria induces cholesterin precipitation. This view is not in accord with the more recent conclusion of Aschoff that cholesterin stones are found exclusively in sterile gall-bladders and Renver's claim that concretions can result from simple biliary stasis. The non-inflammatory stone is usually solitary and is a "radial cholesterin stone," what factors are present besides the stasis is for the present purely conjectural.

Bilirubin-calcium is not a normal biliary constituent, and its occurrence in concretions, therefore, demands a further explanation than the mere presence of bile color. If lime be added to bile the formation of this compound, being hindered by the presence of bile salts, is not accomplished until large quantities have been added; the mere secretion of calcium in excess does not therefore adequately explain the formation. Moreover, calcium is not secreted in excess when it is present in increased amount in the food and drinking water, as has been held. What has been observed is that the presence of albumin overcomes the retarding influence of bile salts on bilirubin-calcium formation; and it seems in all probability that this condition, viz., the presence of albumin in bile, is the deciding factor, both the calcium increase and the albuminous matter being derived from mucus secreted by an inflamed gall-bladder. According to this view, a cholesterin stone remains pure or contains pigment only by absorption so long as it does not give rise to inflammation. When this latter supervenes, outside layers of cholesterin and pigment-calcium are formed and the stone becomes a combination calculus. On the other hand, inflammation induced by infection, if accompanied by stasis, gives rise to a mixed stone, while without stasis it may be largely or wholly composed of pigment-calcium. Hence, in keeping with the improbability of the presence of calcium-albumin without stasis, the occurrence of pure pigment-calcium formation is relatively rare. This view ignores the part played by the bile acids, explained above which latter are destroyed to a varying degree by different bacteria. The infecting agents that have chiefly attracted attention are the colon bacillus and the typhoid bacillus, but it is known that in individual cases the pyogenic organisms as well are intruders. Experimental observations indicate that in a given time the typhoid bacillus breaks up the greatest amount of bile acids, the amounts decreasing with other bacteria in the order: proteus, coli communis, Friedlander, staphylococcus aureus, and streptococcus. According to this view, it follows that the more active organisms tend to mixed stone formation while the least active tend to pure pigment calcium, unless, indeed, they are merely secondary invaders.

Particular interest is attached to the occurrence of gallstones following typhoid fever; it is probable that in some cases the infection of the bile with the typhoid bacillus persists for months and even years, and that in many instances it determines inflammatory conditions of the biliary passages that directly lead to the formation of biliary calculi. It has been suggested that groups of typhoid bacilli become the nuclei of concretions, and observations seem to support this view. If so, it is not improbable that in some instances the bile, which is known to acquire the property of causing the bacilli to clump, actually leads to the formation of nuclei by agglutinating the typhoid bacilli contained in it.

The invasion of the various organs by the colon bacillus is now too well recognized to require argument of the possibility of such an occurrence in the case of the bile passages. Instances are not uncommon in which for some reason the bacillus is particularly virulent and the tissues less resistant than normal, and in which, consequently, the bacteria invade the liver and bile passages. Under these circumstances, especially if associated with stagnation of bile, the conditions are ripe that favor the formation of biliary calculi.

Calculus formation commonly originates from (1) epithelium in bile, (2) sedimentary masses, (3) agglutinated bacilli, or (4) the adhering together of small nodular masses of pure bilirubin calcium or cholesterin. The growth is both by the addition of fresh layers and transformation within the calculus; this is rendered possible by the existence of minute infiltration channels through which there is continuous progressive infiltration with cholesterin and its deposit in crystalline form. Even pure cholesterin calculi do not crystallize directly from solution, but are secondary formations. The layers deposited on the surface of calculi are as a rule, hardly more than one millimeter thick, but if rich in bilirubin calcium they may be five millimeters thick or more. Early in the formation of some calculi, even while they are acquiring a firm crust, changes may occur in the soft interior; either the contents may deposit on the firm crust, leaving a hollow interior, or such a deposit may leave the contents fluid. The growth of the concretion by deposit of bilirubin-calcium ceases when bile ceases to enter the bladder, but the acquisition of cholesterin from the mucous membrane may continue.

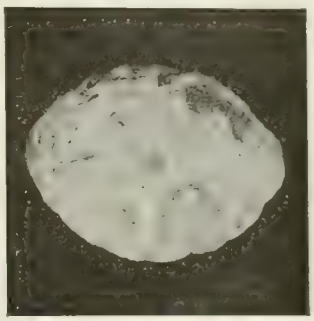

Fig. 1515.—Biliary Calculus from Cystic Duct: from a case of empyema of the gall-bladder. (Slightly enlarged. The actual specimen measured one inch and one-quarter in its long diameter.)

Cardiac calculi, so called, are found in rare instances, at the necropsy, lying free in the pericardial sac. Some are soft and smooth, varying in size from a pea to a bean: others firm, fibrous, occasionally stratified or calcified, either in a central nucleus or throughout. They are regarded either as polypi detached from the inner surface of the pericardium, or as results of fibrinous or calcareous deposits about some foreign substance.

Cutaneous concretions are nodular calcareous deposits in the cutis or still oftener in the hypoderm. They are usually surrounded by capsules of firm connective tissue from which septa extend into the contents of the tumor, dividing it into segments which are made up of calcified cells. True ossification of these septa has been observed, though this is exceptional, they being usually fibrinous or calcareous.

Views regarding the nature of the cellular masses differ according to the explanation of the development of the tumor which the observer accepts. Malherbe believes that the majority of cutaneous stones develop from proliferated and cystic sebaceous glands. Von Noorden reports a stony-hard, pear-shaped tumor, which hung behind the ear by a peduncle and in which the epithelial collections looked like concentric horny pearls and which in spite of its benignancy he classed with carcinoma. Four small tumors of the skin of the scrotum, in a boy of twelve, were regarded by Lewinski as calcified lymph thrombi. While all sorts of degenerated tissue and inspissated secretion may take up calcium salts and lead to the formation of stone, Unna believes that fat and fat products have a special tendency to this, owing to the formation of insoluble calcium soaps by the reaction with calcium bicarbonate of the lymph. He differs from Malherbe in believing that calcifica-

tion involves glands only in so far as they are enclosed in fat lobules.

Skin concretions are of rare occurrence. They have been more frequently found in the aged.

In the course of *gout* a deposit of tophi composed of biurates is common, most often in the kidneys, skin, and subcutaneous tissue, but also frequently in the tendon sheaths, the tendons, ligaments, synovial membranes, and articular cartilages, and ultimately perhaps in nearly every tissue and organ in the body, excepting tissues of the nervous system. The composition is indicated in the following analysis of such a concretion by Ebstein and Sprague.

| One Hundred Parts of Solids Contained: | |
|---|---|
| Uric acid | 59.70 |
| Tissue organic matter | 27.88 |
| $Na_2O$ | 9.30 |
| $K_2O$ | 2.95 |
| CaO | 0.17 |
| MgO, Fe, $P_2O_5$, S | Traces. |

The views of various observers differ as to the cause of the formation of gouty concretions. The earlier view of Garrod and others was to the effect that uric acid is present in undue amount in the blood and separates as tophi owing to the sluggish circulation

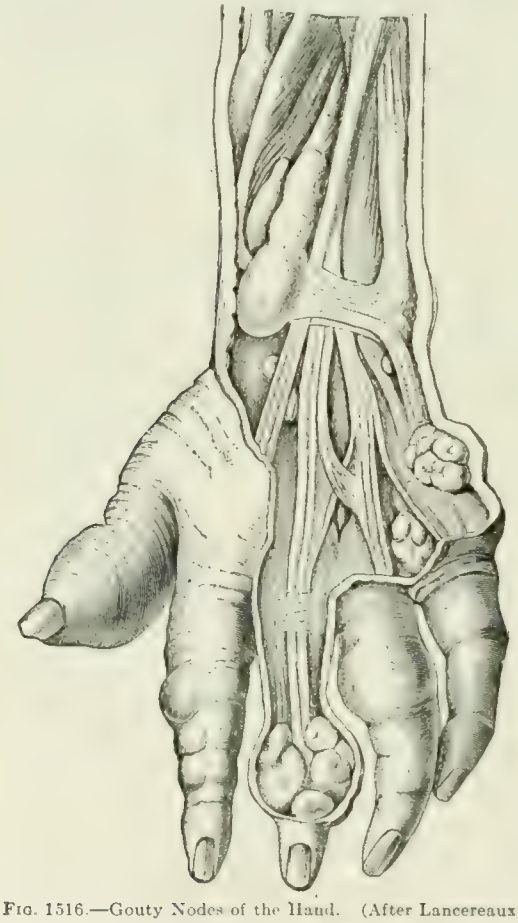

Fig. 1516.—Gouty Nodes of the Hand. (After Lancereaux.)

in the various locations. Ebstein advanced the opinion that the deposit is determined by tissue necrosis preceding the formation of concretions. Others (Bouchard, E. Pfeiffer) hold that diminished alkalinity of the blood is the prevailing etiological factor. Von Noorden believes that tissue necrosis in gouty conditions is of such a kind as to lead to urate formation from cell products at the site of the concretion and that the material of tophi is not directly brought to the area by the blood. It is at least certain that although in leukemia and some other conditions uric acid is formed in the body in large excess, it does not lead to the deposit of the tophi so characteristic of gout (Fig. 1516).

Intestinal calculi, or enteroliths, occur more frequently in herbivorous animals than in man. In certain animals, which have the habit of licking their own coats or those of their associates, the formation in the stomach and intestines of balls of felted hair is not infrequent; these hair balls perhaps attaining considerable size. Commonly, intestinal concretions are found in the colon and are very small, rarely as large as a hazelnut, so that it is very infrequent for them to cause obstruction. We have already mentioned that gallstones may enter the alimentary tract. Various foreign substances are introduced through the mouth and esophagus, a very small percentage of which become nuclei of concretions. In most instances the central mass consists of undigested food residue or inspissated mucus, while the material composing the bulk of the calculus is commonly ammonio magnesium phosphate, perhaps with magnesium phosphate, but may include calcium phosphate and carbonate and occasionally calcium and magnesium soaps and albuminous matter. I have seen one small concretion, which the patient said passed per rectum, which appeared to be identical with urostealith, presenting the characteristic appearance and giving the chemical reactions of this substance. In countries where oatmeal is largely eaten, often as a substitute for bread, intestinal concretions resembling hair balls are not infrequent; they contain calcium and magnesium phosphate, about seventy per cent.; oatmeal bran, fifteen to eighteen per cent.; soaps and fats, about ten per cent.

Oriental "bezoars" are intestinal concretions which probably were formed in *Capra ægarus* and *Antelope dorias*. They are usually spherical or oval and have a dark olive-green color due to biliverdin, with a smooth, shining exterior, and are composed almost entirely of lithofellic acid, $C_{22}H_{36}O_4$, soluble in boiling alcohol from which the acid separates on evaporation as small pointed rhombohedra or three-sided prisms. This acid is insoluble in water and ether, but dissolves in glacial acetic acid. It is closely related to cholalic acid. When heated, true bezoars evolve aromatic fumes.

False bezoars, which come from Eastern countries, have a brownish-black color, do not melt or evolve aromatic fumes when heated, and are composed chiefly of ellagic acid, $C_{14}H_{16}O_8+2H_2O$, probably derived from the tannins contained in the food consumed by the animals which yield them.

Pancreatic calculi are usually small, varying in size from a grain of sand to a walnut; multiple, numbering from one to more than a hundred, and of light gray or white color. They are usually round or oblong, sometimes elongated and branched. The surface may be smooth, rough, or spinous. They are composed chiefly of calcium carbonate, but contain some calcium phosphate and occasionally cholesterin. They may be the cause of pancreatic cysts and chronic pancreatitis.

Preputial concretions sometimes form in those cases in which the prepuce cannot be drawn over the glans, and they usually have for their nucleus dried smegma, around which may be deposited the ordinary constituents of urinary calculi, especially the phosphates. Some of these concretions have been found to consist of dried smegma and epithelial scales: one, analyzed by Zahn, was made up of epithelium, calcium salts, and cholesterin, and another examined by E. Salkowski gave fat, free fatty acids, and calcium salts.

Prostatic concretions, which are of frequent occurrence, may originate in the substance of the gland, may come from the bladder or the urethra, or may be deposited from the urine in suppurating prostatic pouches. Those that are present in the substance of the gland usually originate as the amyloid bodies already described, which indeed are so constantly present in this organ that they can hardly be considered abnormal. As they increase in size, in most instances in later adult life, they excite inflammation and become hardened by the deposition of calcium salts, particularly the phosphate and carbonate. These calculi may lie separately in pouches or several may be together in a common pouch, in which instance they are often adherent or exhibit facets. Their color is brown or black, and the surface smooth and polished.

Those coming from the bladder and those forming from urine present the characters of vesical calculi formed under similar conditions; they consist most frequently of a mixture of calcium and ammoniomagnesium phosphates. Dr. Herbert Barker has described a large prostatic calculus which was pear-shaped, measured four and seven-eighths inches in length and four and five-eighths inches in circumference, and weighed 1,681 grains.

Pulmonary calculi are most frequently found in the lumen of bronchi, but may occur in air vesicles and even on the walls of pulmonary cavities. Those formed in the bronchi are composed of inspissated and calcified mucus or blood, calcified broken-down bronchial glands, or incrustated foreign bodies. In pulmonary cavities or air vesicles a portion of the wall becomes incrusted or impregnated with dust of various kinds and is subsequently thrown off by necrosis. A case of lenticular necrosis in a stonecutter's lung, recently reported, had progressed to the formation of pneumoliths in an apex cavity and their subsequent expectoration. Seventy small, hard, black, angular stones were found at autopsy. They varied in shape and in size up to seven millimeters in diameter.

Rhinoliths are found in the nostrils after chronic inflammation of the mucous membrane; they are usually formed by the deposition of the nasal secretion about foreign bodies as a nucleus and contain a large proportion of organic matter.

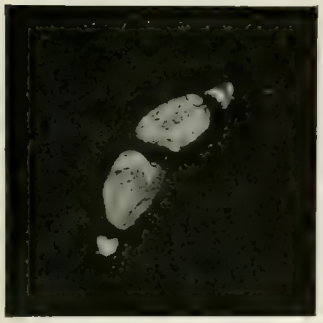

Fig. 1517.—Salivary Concretion from Wharton's Duct. (Natural size.)

Salivary concretions form in the salivary ducts, especially in Wharton's duct, and are usually oblong in shape. They are formed by the deposition of the salivary salts and may reach a large size; one weighing 7.5 grams is recorded. They are composed chiefly of calcium carbonate and phosphate, mixed with epithelium and organic matter (Fig. 1517).

Tonsillar Calculi, amygdaloliths, are sometimes formed in chronic enlargement of this organ in which the inspissated secretion of the crypts has accumulated deep within the gland and remained for a prolonged period of time, undergoing calcification. Fragments of the calculus may be discharged; in some instances the mass has been visible. The formation of a true tonsillar calculus is rare (Fig. 1518).

Urinary calculi are of frequent occurrence. They may be found in any part of the urinary tract, but usually occur in the pelvis of the kidney or in the bladder, and according to their location are designated renal or vesical. They occasionally occur in the kidney substance, in the ureters, or in the male urethra, and have been found in sinuses between the cavities of other organs and the urinary passages. Most varieties are formed by the deposit of normal or pathological urinary solids, and are usually named from the substances of which they are chiefly composed. Thus we designate the following: Uric acid, calcium oxalate, phosphate, urate, cystin, urostealith, calcium carbonate, and xanthin. The formation of concretions is not alone attributable to the mere separation of these substances from the urine, since instances are not uncommon in which copious deposits occur, particularly of urates, uric acid, oxalates, or phosphates, even for long periods of time, without the tendency to form calculi. Another accompanying condition is essential, namely, the presence of an albuminous substance which leads to an

Fig. 1518.—Tonsillar Concretion. (Natural size.)

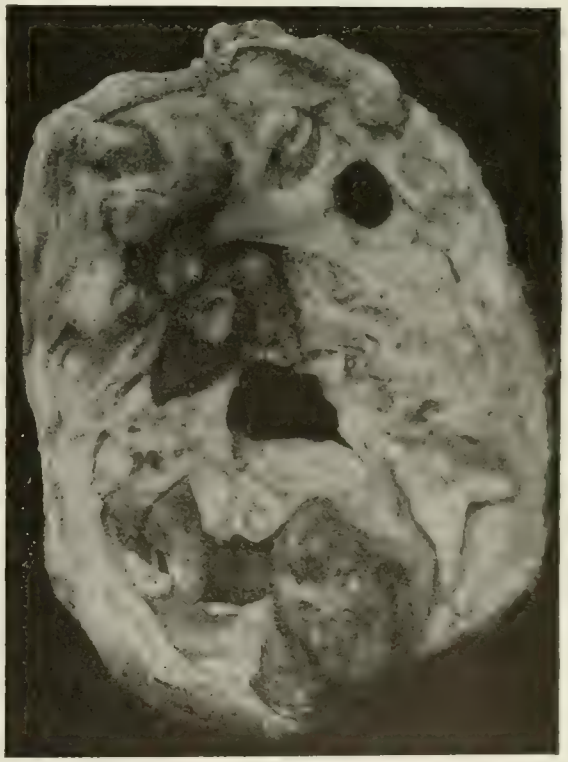

Fig. 1519.—Calculi in Kidney, Conforming in Shape to the Infundibular and Pelvic Cavities. (Natural size.)

agglutination of the separating material in crystallization. Masses thus formed increase in size and become the various concretions with which we are familiar. Further evidence of the importance of this condition is obtained by dissolving out the salts of the calculus without macerating the mass, when an albuminous or

colloid framework will remain. Hence we recognize two primary factors as being essential to calculus formation, namely, a tendency to the separation of certain urinary solids, and the presence of an albuminous substance in the urine which becomes the framework of the concretion (Figs. 1519–1524).

The former factor, that is, the tendency to crystallize, is furnished by a considerable variety of urinary conditions, which will be mentioned in describing the

Fig. 1520.—A Stone from the Urinary Bladder. (Natural size.)

constituents of calculi. The latter is dependent on a condition of renal or vesical irritation by means of which blood and serum, and perhaps undue amounts of mucus, are permitted to enter the urine. It reminds us, in a measure, of the condition essential to the formation of bilirubin-calcium, discussed in describing biliary calculi.

It is not to be understood that calculus formation is always accompanied by albuminuria. Such is not the case. Many instances are clearly recalled in which albuminuria was certainly not detected and probably did not exist. Vesical irritation, for example, introduces not necessarily serum albumin but always considerable mucus, the albuminoid basis of which is not known to us chemically, but which is probably a nucleoproteid of some kind, not mucin as has been so generally stated. That urine contains mucus is a well-recognized fact and is proved by the formation of froth when the urine is shaken. This appears greater in concentrated specimens and in those which have remained long in the bladder. Under conditions of vesical irritation the mucus in urine is materially increased, and doubtless in some instances affords the factor which, as has been stated, is essential for conglomeration of crystallizing urinary solids.

*Uric acid* occurs in the body fluids and in urine in combination with sodium, potassium, or ammonium. The separation of uric acid goes on under certain pathological conditions. Just what the conditions are and just why they operate to effect the result it is difficult always to say, but we believe that at least four conditions tend to accelerate the precipitation—namely, (1) high acidity, (2) poverty in mineral salts, (3) low pigmentation, and (4) high percentage of uric acid; while the opposite conditions tend to retard precipitation.

The acidity of urine is in part due to acid phosphate, which in turn is derived from the basic phosphate of the blood. It may be increased by internal conditions, as, for example, the internal administration or production of acids or by a diminished secretion of acid in the gastric juice, under which conditions the increase is absolute; or it may be relatively increased by a diminution in the volume of water secreted. Acid is produced in prolonged muscular exertion, in diabetes mellitus, and by some of the putrefactive and fermentative changes that food may undergo in alimentation. A diminution in the volume of urine is noted in those who drink little water, in individuals leading a sedentary life, and in those who experience an increased loss of water from the body through other channels, *e.g.* the sweat and bowels. Under these various conditions, then, urinary acidity and the consequent tendency to uric-acid separation are increased, and in the presence of the conditions of vesical or renal irritation already mentioned tend to the production of uric-acid concretions.

The conditions where urine is poor in mineral salts are various. There may be ingestion in small amount or limited secretion from diminished renal

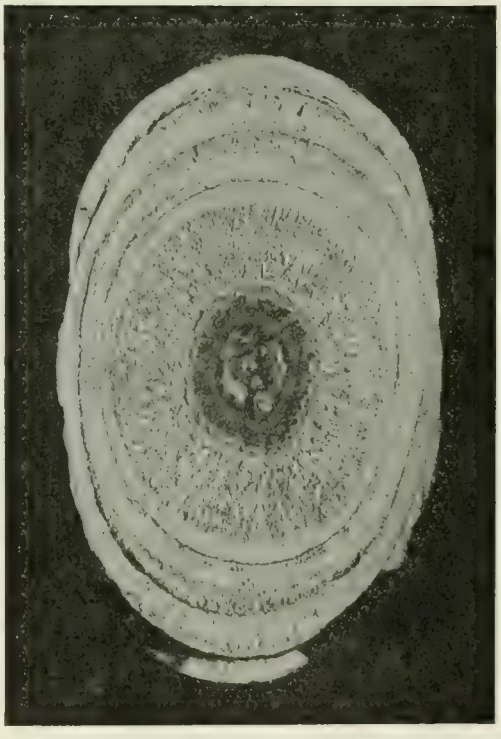

Fig. 1521.—Transverse Section of Fig. 1520. Showing the laminated body composed of magnesium phosphate and a nucleus of calcium oxalate.

capacity. It is known that chlorides are diminished in various gastric disorders, and that in chronic interstitial nephritis the amount of phosphate in urine is below normal. Again, the increase of acidity by internal administration or production of acids may change the character, although it does not decrease the quantity, of the urinary salts.

The pigmentation of the urine is dependent on profound and at present not well-understood metabolic

processes, and is derived more or less directly from the pigment of the blood, bile, and perhaps from the suprarenals. It is relatively low in dilute urine and in diabetes, and appears to suffer absolute reduction in other conditions which have not been carefully studied.

A high percentage of uric acid may be (*a*) relative, from the concentrated character of the urine, or (*b*) absolute, from its increased production in the body. The older view that uric acid originates from suboxidation of albuminous constituents of tissues is not supported by experimental or clinical evidence. It is now generally admitted that it is an end product of the destruction in the body of nucleins, either of body cells or perhaps of the food as well. Increase of uric acid, then, results (1) from the administration in undue amounts of nuclein or purins in food, (2) from an increase of those physiological catabolic processes that result in nuclein decompositions, and (3) from pathological catabolic processes that accomplish this result. Uric acid in health appears to come chiefly from the purins of foods (exogenous origin) and from purin destruction within the body (endogenous origin) such as occurs in the catabolism of nucleins. This physiological process is augmented by those pathological states which bring about undue cellular activity as, for example, many acute diseased conditions, leukemia and certain other blood diseases, malignant growths, and autointoxications such as the digestive autointoxications that are frequently seen in neurasthenia. Pathological processes in which uric acid is formed from local cell necrosis appear to be the cause of the biurate production in various localities in gout. The urate passes into the blood and ultimately to the urine.

Of these four conditions leading to uric-acid separation, the acidity of urine is probably the most important factor. Uric acid is only slightly soluble in urine. With its continuous production in the body and with so many factors interacting to produce its separation from the urine, it is not surprising that the formation of concretions of this substance occurs. Uric-acid crystals have sharp edges and points, and thus tend to be more or less irritating, for which reason it appears that they are especially capable of giving rise to those conditions of irritation of the urinary tract by which the albuminous substances are introduced that we have seen to be essential to the aggregation of the crystallizing material.

Uric-acid calculi vary in size from a grain of sand to a goose egg. The surface is usually smooth, sometimes granular, while the color is yellow or red. They are moderately hard and may be quite irregular in shape, owing both to the shape of the cavity wherein they are contained and to the restricted attrition from motion. They originate in the pelvis of the kidney, but may pass to the bladder, usually causing the violent and paroxysmal pain of renal colic. In the latter cavity they may increase in size by the further accretion of uric acid, or they may enter into the formation of mixed calculi, mention of which will be made below. The formation of uric-acid calculi is most frequent in children and in the aged.

*Urates* are rarely the principal ingredients of urinary stones, such calculi being observed almost exclusively in children. The urate infarcts of the newly born may form true stones in the substance of the kidney, but most urate calculi are found in the pelvis or the lower part of the urinary tract. They are moderately soft, rarely large, and are grayish yellow in color.

Urates ordinarily separate from urine as a copious deposit, usually amorphous but occasionally crystalline, and are tinted a brick-red color by uroerythrin, their separation being dependent solely on their solubility and not on such a variety of conditions as we have seen to determine uric-acid precipitation. Consequently urate deposits are nearly always observed in concentrated urines. If the urates are increased by systemic conditions which have already been considered in connection with uric acid, the tendency to precipitation is thereby increased. Usually sodium is the base present, perhaps together with small amounts of potassium and ammonium, and even traces of calcium and magnesium. The ammonium salt is much more apt to deposit in urines which have undergone ammoniacal fermentation, separating as spheroidal clumps with projecting spines. The aggregation of the precipitating urates into calculi is apparently subject to the same conditions as determine the formation from other constituents.

*Calcium oxalate* forms the hardest and probably the most frequent of all urinary stones. They are rarely large, and are more or less spheroidal in shape if

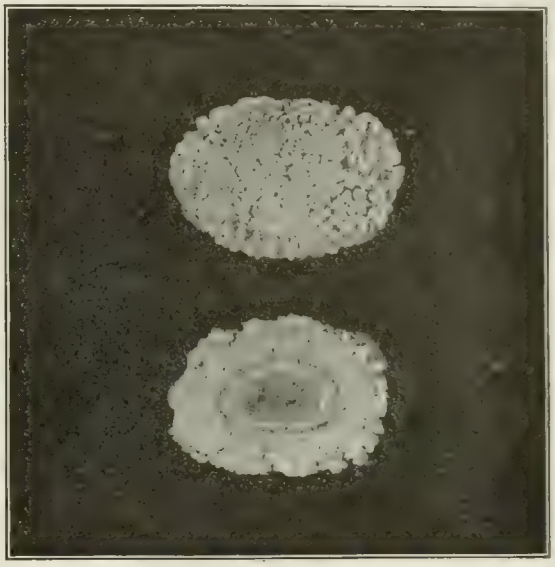

Fig. 1522.—Calculus of Calcium Oxalate. External view and section. (Natural size.)

single, facetted if multiple, and have either a rough, tuberculated surface, giving rise to the name of "mulberry" calculi, or less often they are small, rounded, smooth bodies known as "hempseed" calculi. They are usually dark brown or black, but may be light in color and may form in acid urine about a nucleus of epithelium or more commonly uric acid. Amorphous urates and phosphates may be deposited between the tuberculations. They have been found in the secreting substance of the kidney, but are usually formed in the pelvis, from which locality they may pass to the lower urinary tract. They probably never occur excepting in patients with oxaluria, a diathetic condition existing in certain neurotic states, particularly those associated with indigestion, and which, I believe, is always dependent on digestive disturbance. With the exception of the physiological oxaluria following the administration of oxalate in the food, it is probable that oxalic acid is formed in part or wholly from food in alimentation, chiefly from carbohydrates, by bacterial activity. Thus the administration of undue amounts of cane sugar is in certain individuals followed by the appearance of a copious deposit in the urine of crystals of calcium oxalate. It is further noticeable that such individuals are apt to suffer from hyperchlorhydria, an important connection when it is remembered that certain bacteria, including the colon bacillus, which tend to produce putrefaction of protein matter in neutral or slightly acid media, direct their activities chiefly or wholly to the fermentation of carbohydrates in more strongly acid solutions.

Gordon's view that calcium metabolism is a factor in the genesis of oxalate calculi assumes that calcium in excess may be derived from the ingesta or from calcium-containing tissues. This is in direct opposition to the view that the formation is due to calcium fixation, since in treatment, according to the former, calcium is to be avoided while with the latter view, it may be administered not alone for its diuretic effect but as well to replace the calcium of which the tissues have been deprived. Moreover, where oxalate is formed in the alimentary tract, an abundance of calcium in the food assures the fixation of the oxalate before absorption and hence its elimination by the bowel. Moreover, calcium fixation explains the action of certain mineral waters reputed to be valuable therapeutic agents in cases of calculi and which chemically are characterized by the abundance of their calcium salts. It also emphasizes the necessity of exact reproduction where artificial are to replace the natural waters.

*Phosphatic concretions* occur next in frequency to oxalate calculi. They are composed of calcium phosphate, ammonio-magnesium phosphate, or both; are nearly always vesical in origin, and are usually formed in ammoniacal urine. For this reason they, together with other calculi dependent upon this urinary change for their formation, are spoken of as secondary concretions, in contradistinction to the primary calculi that separate in urine which has not undergone alkaline fermentation.

Fig. 1523.—Coral-shaped Stone from the Bladder, Composed of Oxalate and Phosphate of Calcium. (Natural size.)

Phosphates are normal constituents of urine, in which they exist as soluble salts of the alkalies (about seventy-five per cent.) and salts of the alkali earths, calcium and magnesium; they are soluble only in acid urine. It is this latter portion that tends to separate, not, however, from the presence of an excess of phosphate or of calcium and magnesium, or because of a concentrated condition of the urine, but owing to the absence of acidity of this fluid. In cystitis, for example, in which the urine is ammoniacal from decomposition, phosphates of the alkali earths are precipitated; and since this pathological state is so generally associated with vesical irritation, the condition is favorable to the agglutination of the separating phosphate into calculi. From what has been said it is apparent that the introduction of calcium into the body, as in the use of hard drinking-waters, can have no influence on the formation of these urinary concretions, as was at one time supposed to be the case.

The ammonio-magnesium salt, the so-called triple phosphate, is commoner in calculus formation than calcium phosphate, although calculi composed exclusively of the former are uncommon. Those occurring are not as a rule of marked size. Being formed in ammoniacal urine only, they are vesical in origin and frequently complicate cystitis.

Calcium phosphate only occasionally forms unmixed concretions. The structure of the latter may be compact or spongy. Two forms occur: 1. Round or oval, varying in size from a small bean to a hen's egg. They have a white, chalky appearance and break with an amorphous fracture. They are of vesical origin, and are more frequent in elderly people, especially dyspeptics. 2. Irregular, sometimes branched, usually of a grayish-white color, compact in texture, brittle, and with a porcelain-like fracture. They are usually found in cysts and pockets of the urinary tract and seem to be of local origin.

By far the most common phosphatic calculi are those of the mixed variety containing both calcium phosphate and triple phosphate; these calculi often attain a large size. Under the blowpipe they fuse to a black, enamel-like mass, and hence have been termed "fusible calculi." They have a grayish-white color, are friable and somewhat spongy, and are often composed of concentric laminæ. The outside and fracture surfaces may present bright, glistening points, triple phosphate crystals. They usually form about a nucleus of different composition.

Phosphatic calculi are exceptionally formed within the urethra, in which locality they are most frequently observed in infancy and after middle age. Their common seat is in the bulbo-membranous and prostatic regions and in the navicular fossa; they rarely form behind a stricture, but rather in urethral pouches and diverticula. The growth from incrustation is backward. As they increase in length they may be segmented by fracture, eventually forming a row of calculi that articulate with one another. There is usually a constriction at the vesical neck back of which the growth may extend in the bladder in any direction, the calculus eventually becoming mushroom-shaped or taking on the appearance of two nodules connected by a bar.

In pyonephrosis, in which ammoniacal fermentation of urine occurs in the pelvis, there is the same tendency to the formation of phosphatic calculi as when this change occurs, as it more commonly does, in the bladder.

*Calcium carbonate calculi*, which are so often found in other parts, are rarely found in the urine of man, but occur more frequently in herbivora. When found they have been multiple, small, weighing hardly more that two or three grams each, with a smooth surface and resembling somewhat calcium oxalate stones, being hard and lamellar in structure. They are usually round, often translucent, and on section present numerous concentric lines and a multiple nucleus. On crushing they break into sharp fragments.

*Cystin calculi* occur but seldom. They are of primary formation, have a smooth or rough surface, are white or pale yellow, have a crystalline structure, and vary in size up to that of an egg. They are not very hard, but break with a crystalline fracture. On section they present a radiated surface of yellow color which turns gray on exposure to light. The occurrence of cystin is pathological. There appears to be a peculiar putrefaction within the intestine in cystinuria, leading to the formation of cadaverin and putrescin. Whether this is connected with the formation of cystin is uncertain but probable. During the formation of a cystin calculus, the characteristic hexagonal crystals of cystin are usually found in the urinary sediment. There appears to be a tendency to the formation of cystin calculi in members of the same family.

*Indigo concretions* have been met with in the urinary passage in one or two instances. The material for such a stone is derived, presumably, from the indican of the urine. This substance, which is indoxyl potassium sulphate, originates from indol, a product of the putrefaction of albuminous matter, usually in the intestines, and on oxidation readily yields indigo. In certain chronic diseased conditions within this organ it is continuously increased in the urine many times the usual amount.

*Urostealith calculi* consist of fatty matter in an amorphous or crystalline condition. Their occurrence is so exceedingly infrequent that their existence has been questioned; thus, Krukenburg found that what appeared to be a fatty concretion consisted in fact of paraffine derived from a paraffine bougie. That they do exist the writer is prepared to affirm from the fact that in a case in which one was passed

he afterward found another at necropsy embedded in the tissue of the cystic kidney. Horbaczewski has recently analyzed one as follows:

| | | |
|---|---|---|
| Water | 2 5 | per cent. |
| Inorganic solids | 0 8 | per cent. |
| Organic solids insoluble in ether | 11.7 | per cent. |
| Organic solids soluble in ether | 85.0* | per cent. |

* 51.5 per cent. fat acids (stearic, palmitic), 33.5 per cent. neutral fat (myristic), trace of cholesterin.

At the temperature of the body these calculi are soft and elastic, for which reason they do not produce colicky pains when passing through the ureters. At ordinary temperature they are brittle, soft, have an amorphous or glassy fracture, and are translucent.

*Xanthin calculi* are exceedingly rare, less than a dozen being recorded in the literature. Their occurrence has been confined to young subjects. The calculi observed have been either pure, or mixed with uric acid, which xanthin so closely resembles. The size has varied from a pea to that of a hen's egg, and the color from whitish to dark brown. They have a medium hardness, amorphous fracture, and on rubbing take on a waxy appearance.

Calculi composed of *fibrin, blood,* or *inspissated albumin* are mentioned as having been met with in urine. They have a glassy fracture. Their occurrence must be regarded not only as unusual, but as anomalous.

In the description of the various urinary concretions very little has been said of the formation of mixed calculi. As a matter of fact, calculi are not commonly composed of a single constituent. The location of their formation and growth and the attending conditions upon which their formation depends so change from time to time that different substances enter into their structure, and the result is the formation of mixed calculi. Uric acid and calcium oxalate most frequently form calculi consisting exclusively of one ingredient; on the other hand, calculi composed of separate and alternating layers of these two substances are the most common example of the so-called "alternating" calculus.

The different deposits may be primary, primary and secondary, or secondary. They almost invariably have a central nucleus, while the substance of the calculus, the body, may be surrounded by an external layer or crust which is nearly always phosphatic. The nucleus varies in composition and in size. It may not differ from the body, especially in primary calculi, and on the other hand may even consist of bits of tissue, as blood clots, epithelium, or inspissated mucus. Exceptionally, foreign bodies which have found their way into the bladder become nuclei (Fig. 1524). A calculus was recently observed in which the nucleus was a snake's tail which a patient had been advised to pass into his urethra for the cure of a stiffened right arm. A form of mixed calculus that is very common is the phosphatic concretion that results from ammoniacal urine. A primary calculus, entering the bladder, or exceptionally forming within this organ, produces there such vesical irritation as eventually to give rise to cystitis with ammoniacal fermentation of the urine leading to the deposit of phosphate upon the primary formation.

Fig. 1524.—Pin Forming the Nucleus of a Calculus Composed of Calcium Phosphate, Uric Acid, and Dried Blood. (Natural size.)

Examination of Urinary Calculi.—Before proceeding to the analysis it is always well to record the color, hardness, appearance on section or fracture, and perhaps the specific gravity of the specimen. The appearance of a powdered or fractured portion under the microscope may also be of value. In the case of mixed calculi, each layer should be examined independently. The chemical analysis may be conducted as follows:

Heat a small portion of the powder on porcelain or platinum.

*A. The material burns away, leaving little or no residue.*

1. It melts, burns with a smoky flame, emitting an aromatic odor. It is soluble in ether, the ether leaving a fatty residue on evaporation. It is soluble in potassium hydroxide. *Urostealith.*

2. It gives off purple-red vapor. The material is soluble in sulphuric acid with the formation of a blue color, the solution showing a band before D in the spectroscope. *Indigo.*

3. It gives the odor of burning feathers. The material responds to tests for proteins: *e.g.* Millon's xanthoprotein. *Albumin, fibrin, blood.*

4. A fresh portion, when treated with hydrochloric acid, dissolves completely.

(*a*) Also soluble in ammonia. Filtration and evaporation to remove ammonia produce a separation of hexagonal crystals. These may also be obtained by acidifying the ammoniacal solution with acetic acid. *Cystin.*

(*b*) Dissolve a fresh portion in nitric acid, evaporate to dryness in a porcelain dish over a water bath, moisten yellow residue when cool with potassium hydroxide, and an orange-red color is produced which becomes reddish-violet when heated. *Xanthin.*

5. A fresh portion, when treated with hydrochloric acid, does not dissolve completely. Filter and test the filtrate as described under 4.

(*c*) After washing the residue on the filter, dissolve in nitric acid and evaporate to dryness. The yellow residue turns red when exposed to the vapor of ammonia, and the addition of potassium hydroxide produces a bluish-violet color which disappears on standing. *Uric acid.*

(*d*) In addition to the test for uric acid, the fresh material gives reactions for ammonia *e.g.* when heated in solution with potassium hydroxide, ammonia fumes are given off as recognized by the smell, bluing of red litmus, and production of white fumes with a rod moistened with hydrochloric acid. *Ammonium urate.*

*B. The material may or may not blacken and leaves a considerable residue.*

6. The original material dissolves completely in hydrochloric acid.

(*e*) With effervescence. The solution made alkaline with ammonia yields a white precipitate on the addition of ammonium oxalate. *Calcium carbonate.*

(*f*) Without effervescence.

(1) The ignition residue, treated with water, dissolves in part to a strongly alkaline solution and dissolves wholly in acetic acid with effervescence. Addition of ammonium oxalate to this acetic-acid solution produces a white precipitate. *Calcium oxalate.*

(2) The ignition residue, treated with water, does not dissolve in part to a strongly alkaline solution. It dissolves in acetic acid without effervescence. If the nitric acid solution of the original material is added to an excess of ammonium molybdate solution in nitric acid a yellow precipitate is formed when the mixture is warmed. *Phosphate.*

The solution in acetic acid obtained above or of the original material yields a white precipitate on the addition of ammonium oxalate. *Calcium phosphate.*

The filtrate from the calcium oxalate yields a precipitate when rendered alkaline with ammonia. The original material, when moistened with potassium hydroxide, does not give reactions for ammonia. *Calcium and magnesium phosphate.*

The above reaction for ammonia is strongly positive and magnesium is present. *Ammonio-magnesium phosphate* (triple phosphate). If calcium is present as well there is an admixture of calcium phosphate.

7. The original material does not dissolve completely in hydrochloric acid.

Uric acid is present and may be tested for in the residue by the murexide test described in 5 (*c*). When a platinum wire is moistened with the hydrochloric acid solution and then introduced into a Bunsen flame, a yellow coloration of the flame is produced owing to the presence of sodium. *Sodium urate.* Traces of potassium urate and even the ammonium, calcium, or magnesium salt may be present.

Note.—The application of the foregoing scheme to the analysis of mixed calculi may call for such slight modifications of the procedure as will be apparent.

E. E. Smith.

**Condurango.**—The dried bark of *Marsdenia condurango* Nicholson, syn., *Gonolobus condurango* Triana (fam. *Asclepiadaceæ*). This plant is a medium-sized, milky-juiced, woody twiner of Ecuador and neighboring parts of South America. The bark was introduced as a specific for cancer, due apparently to the loose application of this term, in South America, to various minor ailments. Its trial resulted in disappointment, notwithstanding that it produces some favorable results as an alterative, in cancerous as in other diseases. Besides containing a considerable amount of resin, *condurangin* has been described as an amorphous, yellowish glucoside. This is now believed to consist of a mixture of two or more glucosides, which are similar in action, producing incoordination and loss of movement. Their therapeutical application has not been demonstrated. They are soluble in both water and alcohol. Condurango is an excellent stomachic, though only mildly bitter. Weak alcohol is the best menstruum. The average dose is gr. xxx. (2.0).

Henry H. Rusby.

**Condyloma.**—A term used specifically for *condyloma acuminatum* (*Synonyms:* Verruca acuminata, venereal wart, pointed wart, pointed condyloma, fig wart, cauliflower excrescence; Fr., végétation dermique; Ger., Spitzencondyloma, Spitzenwarze, venerische Warze; Feigwarze) and generally used to include both *condyloma acuminatum* and the syphilitic lesion, *condyloma latum.*

Condyloma acuminatum is a benign outgrowth of the epithelium and connective tissue of the skin and mucous membranes, occurring especially about the genitalia. It is characterized both by the marked proliferation of the prickle-cell layer, so that Unna speaks of it as a "pure acanthoma," and by the very slight degree of horny change in the superficial layers.

In the male condylomata occur especially upon the glans penis, the inner surface of the prepuce, and in the coronary sulcus. In the female they are found about the vaginal orifice, upon both greater and lesser labia, perineum, thighs, and about the anus. More rarely they are seen upon the vaginal wall and the portio vaginalis. Extragenital condylomata have also been described and in some cases have been microscopically verified. Heidingsfeld reports two verified cases of condyloma acuminatum linguæ, and similar growths have also been found between the toes, in the axilla, about the umbilicus, and in other regions where a moist condition of the skin is maintained.

The pointed condylomata exhibit the greatest variety of size and form. The smallest are barely visible, while the more luxuriant may form masses larger than an orange. They begin as reddened elevated areas which become fissured as growth proceeds. The base of the growth branches again and again, producing a typical cauliflower-like mass which continues to spread peripherally by the formation of new papillæ and the subdivision of the old. The mass as a whole may assume a variety of forms depending upon its location and the character of the pressure to which it may be subjected. If it arises from a narrow elongated base or is subjected to lateral pressure it may take on the cockscomb appearance which is frequently seen. When more freely growing a cauliflower growth or a hemispherical mass is the usual type. The peripheral spread seems to be determined in part by the creases and folds in the skin, contact between skin surfaces favoring the extension of the lesion. In general, the possibility of growth seems unlimited and there is little tendency toward spontaneous disappearance.

The color of the growth depends upon its location and the attention given to cleanliness. If kept moist with discharges so that the superficial epithelium is somewhat macerated the color will vary from a pink to a dusky red with even a purplish tint. Or the discharge may dry upon the surface, forming a brownish crust. If the base becomes twisted or is severely pressed upon, the circulation may be so impeded that stasis results and the condyloma becomes purplish-red in color. This may be followed by necrosis and ulceration. Upon surfaces where the growth is freely exposed and can be kept dry the superficial layers show more cornification and the color is like that of normal skin. Such growths have a much firmer consistency than those continually bathed in discharges.

Fig. 1525.—Condyloma Acuminatum. Microphotograph of a longitudinal section of a single papilla. Zeiss, obj. "B."

The *histological picture* is very constant and serves to emphasize the fact that the pointed condyloma is a pathological entity. The epithelium rests upon a framework of branched papillæ which are made up of a very loose connective tissue with numerous dilated blood- and lymph-vessels. Some inflammatory reaction is always present, as is evidenced by a leucocytic and mast-cell infiltration. Among the leucocytes, eosinophiles are usually numerous. This infiltration, with the proliferation of new blood-

vessels and the character of the stroma, emphasizes the analogy of condylomata with the chronic infective granuloma. The epithelial layer is much increased in width, due to a remarkable proliferation of the cells of the prickle-cell layer. Here numerous mitotic figures are to be found and the cells are many of them much larger than normal, in addition to being increased in number. The horny layer is usually present but not increased in thickness and the most superficial cells retain staining nuclei. The pathological change is therefore an acanthosis and not a hyperkeratosis.

The origin of the connective-tissue papillæ and the part played by them in the formation of the growth has been a matter of controversy. Unna maintains that the papillæ are formed by the ingrowth of folds of epithelium and take no active part in the growth of the condyloma. The elongation of the papillæ he believes to be a secondary change resulting from the pressure exerted by folds of proliferating epithelium. Heidingsfeld has called attention to the fact that this explanation would be adequate if the elongation of the papillæ extended only below the normal level of the epidermis, but that in an extensive condyloma some of the papillæ may rise an inch or more above the normal level. He therefore concludes that there is an absolute increase of the connective tissue and that the hypertrophy of the papillæ is an active and not a passive process. If this latter view is correct, we are justified in applying the term "papilloma" to these growths, but if the view of Unna is accepted the condyloma is in no sense a papilloma and this term should not be applied.

The *etiological agent* remains unknown although condylomata are most frequently found in cases of gonorrheal vaginitis, vulvitis, balanitis, urethritis, etc., and the gonococci have been demonstrated in these growths. It has been shown, however, by Bumm, Rasch, Neuberg, and others that condylomata may occur without gonorrhea, but the gonorrheal discharge and perhaps the gonococcus itself undoubtedly influence the development of condylomata. Various organisms have from time to time been described as the causal agent. The supposed psorospermiæ of Ducrey and Oro proved to be cellular degeneration products. Streptococci were described by Fabris and Fiocco. More recently Dreyer, Juliusberg and Schucht, and Hecht have found in these lesions various types of spirochetes, some of which morphologically resemble *Spirochæte refringens*. Hecht concludes that it is impossible to assume for such spirochetes any direct relationship to the etiology of pointed condylomata. This he bases upon the fact that the spirochetes found in the epithelium and appearing to be morphologically transition forms from *Sp. refringens*, are only rarely found in the connective tissue and cannot be found at all in some young fresh condylomata or in some older and dryer growths with cornified epithelium. There is a growing belief in the contagious nature of condylomata. Kranz reported positive results from inoculation experiments, but doubt has been thrown upon these by the work of Petters, Güntz, and Bumm. Numerous cases of apparent contagion and autoinoculation have been reported by Cathcart, Fabris, Fiocco, and Neuberg.

The *symptoms* of condyloma are primarily those of the accompanying inflammatory condition. According to their situation they may interfere with micturition, defecation, coitus, or childbirth. Within a tight prepuce the growth of condylomata may result in a marked degree of phimosis, and retention of secretion may be followed by pronounced inflammatory reaction, gangrene, sloughing, and perforation of both outer and inner layers of the prepuce. During pregnancy condylomata frequently grow to an enormous size. Because of their great vascularity and the softness of the epithelium the traumatism of childbirth may provoke very severe hemorrhages. During the puerperium condylomata frequently undergo rapid spontaneous involution.

The typical distribution and characteristic appearance of the pointed condylomata render their *diagnosis* an easy matter. Where ulceration has occurred, the absence of an indurated border and of glandular involvement will aid in differentiating from carcinoma. In a doubtful case this differentiation should receive microscopical verification. As seen under the microscope an intact basement membrane and absence of any true infiltrative proliferation rules out carcinoma. The marked acanthosis and slight degree of keratosis differentiate condyloma from verruca vulgaris.

The *treatment* of condyloma acuminatum depends primarily upon keeping the parts clean and dry. If there are but a few small lesions this may prove curative. After each cleansing boric acid either alone or combined with alum or other astringents may be freely used. Dusting with calomel, painting with five to ten per cent. salicylic acid in equal parts of alcohol and water, or with a solution of subacetate of lead have also been used. If these are unavailing more vigorous measures may be tried, such as nitrate of silver, glacial acetic acid, chromic acid, or nitric acid. Ligation of the pedicle, destruction by the Paquelin cautery, and repeated transfixion with the electric needle have been made use of. If the lesions are large or numerous surgical excision should be recommended. The smaller condylomata may be removed with the curved scissors, touching the base with caustic to control bleeding. The larger masses should be excised with the portion of the epithelium from which they arise.

Condyloma latum (flat condyloma, moist papule) must be strictly differentiated from condyloma acuminatum. The flat condyloma is entirely a syphilitic lesion and occurs about the genitalia, perineum, anus, axillæ, beneath the breasts in women, and wherever there are heat and moisture between opposing skin surfaces. They appear as flat, button-like lesions with a broad base, and are closely approximated to the skin. The surface is usually smooth, moist or even somewhat macerated, and brownish gray in color. The broad base, the rather sharply rising sides, and the smooth plateau-like character serve to differentiate this lesion from condyloma acuminatum. At times the surface of the flat condyloma becomes somewhat roughened producing a papillomatous or vegetating papule which must not be confused with the pointed condyloma.

Condyloma acuminatum and condyloma latum frequently are found occurring together about the genitalia.

CARL VERNON WELLER.

**Confectiones.**—Confections are soft solids prepared with finely powdered sugar, containing one or more medicinal substances. They were formerly known as *electuaries* and *conserves*. There are two confections official in the U. S. P.

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| Confectio Rosæ (Confection of rose). | Red rose 8, sugar 64, clarified honey 12, stronger rose water 16. |
| Confectio Sennæ (Confection of senna). | Senna 10, cassia fistula 16, tamarind 10, prune 7, fig 12, sugar 55, oil of coriander 0.5, water q.s. |

R. J. E. SCOTT.

**Conglutination.**—In 1906 Bordet and Gay discovered that washed guinea-pig corpuscles in the presence of suitable amounts of both fresh horse serum and heated (56°) bovine serum were not only rapidly

hemolyzed but also exhibited marked clumping and sticking to the sides of the test-tube. They believed that the alexinized and sensitized corpuscles formed a complex capable of binding a substance in heated bovine serum. This substance led to their agglutination. In the same year Muir and Browning observed strong agglutination of ox corpuscles upon the addition of immune serum from the rabbit and fresh ox serum. They called this "the action of complement as agglutinin." In order to prevent confusion of this reaction with ordinary agglutination the term conglutination has been proposed and the substance in the ox serum which brings about the reaction has been called conglutinin. The corpuscles of other animals can be substituted, and there is also a bacterial conglutination. Conglutinin is fixed only in the presence of alexinized and sensitized antigen and in this sense agglutinin is specific, conglutinin non-specific. Conglutinin is easily precipitated, agglutinin is not. Conglutination is more delicate than agglutination, that is, it takes place in the presence of a smaller amount of sensitizer. The application of the reaction to diagnosis has been made and in the bacillary dysentery of infants it is stated that it is far superior to agglutination and complement fixation from the standpoint of early diagnosis. The quantity of conglutinin varies in different animals. Its presence in human serum is uncertain. RALPH G. STILLMAN.

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**Congresses, International.**—The subject of internationalism has loomed large during the past quarter of a century, and medicine, as well as the other sciences, has felt its influence. With the gradual widening of the idea of association for the discussion of medical topics and professional interests and with the growth of societies, from the local to the provincial and from the provincial to the national, it was inevitable that the time would come when the comity of medicine should be world wide and medical men from all the nations of the earth should come together periodically for the mutual exchange of views and the formation of bonds of friendship and amity.

To France, however, belongs the credit of having first given practical expression to this conception. At a meeting of the Medical Society of France in Bordeaux in 1865, under the presidency of Professor Bouillaud, Dr. Henri Guitrac suggested that, as many foreign medical men would probably visit the international exhibition to be held in Paris in 1867, the occasion would be opportune to gather them together for a discussion of matters of universal interest. The proposal was warmly seconded by Bouillaud, and through him an invitation was sent to the leading medical men in Europe and America and to the officers of the National Medical Societies to join with the French Medical Society in the organization of an

INTERNATIONAL MEDICAL CONGRESS.—The *First Congress* was accordingly held in Paris, August 16-28, 1867, under the Presidency of Professor Bouillaud. Its membership comprised 333 French and 589 foreign medical men, so that it may truly be called international—a characterization that did not so well fit the first few succeeding congresses. It so chanced that the first paper to be read was well worth the honor of leading the entire series of congresses. It was by Villemin, discoverer of the inoculability of tubercle, upon his favorite theme. Rollet of Lyon proposed the formation of an International General Prophylaxis of Venereal Diseases, but he appears to have been far ahead of his time, for it was not until the seventeenth Congress, in 1913, that a serious and concerted effort was made in this direction. Among other questions discussed were: Tuberculosis in different countries, and its influence on mortality; the influence of alimentation, climate, race, and conditions of life in different countries, upon disease. During one of the sessions, Dr. Pantaleoni, a delegate from Italy, expressed the wish that this international meeting of physicians might be the first of a long series, thus originating the idea of periodical international medical congresses, and he invited the Congress to assemble in Florence two years later.

The *Second Congress* was held at Florence, the then capital of Italy, from September 23 to October 2, 1869, under the presidency of Professor De Renzi. The attendance was overwhelmingly Italian. Seven questions were discussed among which were: Marshmiasm, the conditions favoring its development; its effects and the most efficient methods for combating it; the therapeutics of cancer; the treatment of gunshot wounds; the hygienic conditions of hospitals; the conditions favoring epidemics in large cities, and the means for prevention; the rights and duties of physicians in regard to legislation in different countries, and the ameliorations which can reasonably be expected therefrom. The most notable paper was one by Lombroso on Pellagra.

The *Third Congress* was delayed four years, that it might be held at the time of the Vienna Exposition of 1873. The Congress was rather one of German-speaking physicians than an international assembly, for very few foreign physicians were in attendance. The session was held during the week of September 1–8. Rokitansky presided. All the questions for general discussion at this meeting related to hygiene. The establishment of quarantine by land and river, and the maintenance of sea quarantine were favored, and the Congress suggested the formation of an international commission for the investigation of the cholera virus. Compulsory vaccination was also recommended to the European governments.

The *Fourth Congress* was held from September 19 to 25, 1875, at Brussels, under the presidency of Dr. J. E. Vlemingkx. In this Congress various sections were organized for the discussion of subjects belonging to the special branches of medical science. At this Congress also the first exposition of drugs, instruments, and other appliances was held, and for the first time there were a number of delegates from the governments of the various countries. The principal topics of discussion were the prevention of cholera, the rôle of alcohol as a therapeutic agent, surgical anesthesia, the organization of a public health service, and the disposition of the criminal and dangerous insane.

The *Fifth Congress* took place at Geneva from September 9–15, 1877. Prof. Carl Vogt was elected president. Perhaps the importance of Switzerland as a place of resort had something to do with a relatively increased cosmopolitan attendance, although the total membership was only about 500. Professor Bouchard read a paper on the etiology of typhoid fever, calling attention to its dissemination by water; Broadbent discussed cerebral localization; Esmarch discussed the advantages and disadvantages of his well-known bloodless method of operating; Hayem read a paper on the composition of the blood; Magnan one on alcoholism as a cause of insanity; Holmgren illustrated his views on color-blindness, and Paquelin demonstrated the use of his cautery. There were six sections.

The *Sixth Congress* took place at Amsterdam, from September 7–13, 1879, under the presidency of Donders. The membership was under 500, but comprised a large foreign contingent. The fact stands forth that numerous medical men of eminence had begun to follow up these Congresses;

they had, as it were, found it worth while. This Congress was marked by Lister's discourse on his antiseptic method of handling wounds, and also by Virchow's address upon the preliminary education of physicians. Professor Donders, the President of the Congress, spoke on the condition of medical science, and emphasized the importance of experimental physiology to its future growth. Sayre of New York gave a demonstration of the application of his plaster-of-Paris jacket in spinal diseases. Hydrotherapy in fevers was discussed, and Bright's disease was discussed at length, Semmola contending that the disease was general, and only secondarily local.

The *Seventh Congress* was held at London, from August 3–9, 1881, under the presidency of Sir James Paget. It had a membership of 3,182, and was of all the congresses up to that time the most successful. The Lord Mayor's dinner at the Mansion House, the soirée at the Guildhall, and the conversazione given by the English members at South Kensington were the chief social functions. By a large majority, the committee decided to limit the invitations to the Congress to men, which brought out a protest from forty-three duly qualified medical women. Pasteur reported upon his investigations of chicken cholera, and upon protective inoculation against splenic fever. Virchow spoke on vivisection as an indispensable aid in research, and made a powerful plea for perfect freedom of investigation, showing conclusively that our present knowledge of life is the result of experimentation, and that the only reliable and practical method for the increase of that knowledge is also experimentation. Professor Huxley gave an address upon the relation of the biological sciences to medicine. Other speakers at the general sessions were J. S. Billings of the U. S. Army, Jenner, Donders, and Volkmann. The scientific work of the Congress was divided among fifteen sections, namely, Anatomy, Physiology, Pathology, Internal Medicine, Laryngology, Surgery, Obstetrics, Diseases of Children, Mental Diseases, Eye and Ear, Skin, Teeth, State Medicine, Military Medicine and Surgery, and Materia Medica and Pharmacology. The number of papers presented was enormous. Barlow described the disease which goes by his name, Erb opened a discussion on the syphilitic cause of locomotor ataxia, Czerny described gastric surgery, while for the U. S. Bigelow demonstrated his lithotrite and Martin his rubber bandage.

The *Eighth Congress* was held at Copenhagen, from August 10–16, 1884, a triennial sequence having replaced the old biennial order. The attendance was over 1,700. Professor Panum of Copenhagen was the president. Pasteur described the results of his protective inoculation of dogs against rabies. Sir William Gull of London advocated international collective investigations of disease. Antiseptic methods came in for a full discussion, which was opened, in the absence of Lister, by Esmarch. Virchow spoke on metaplasia. Sayre demonstrated again his plaster-of-Paris jacket. Tommaso Crudeli exhibited specimens of malarial blood showing aniline stained inclusions in the red blood cells, which he regarded as the germs of the disease. Macewen described his operation for genu valgum. The sectional plan was carried out and the result was both a numerous and a cosmopolitan attendance. At this meeting the invitation was given to hold the next Congress at Washington.

The *Ninth Congress* was held September 5-10, 1887, at Washington. The attendance of foreign members was, because of the distance, and for other reasons, small. The Congress was opened by President Cleveland, and Dr. N. S. Davis was elected president. Compared with other Congresses the principal distinctive features of the medical work were the large number of papers, their almost exclusively "practical" character, and the large number taking part in the discussions. Professor Kōrōsi read an address on vaccination, and showed that compulsory vaccination in the United States might be expected to save 120,000 lives, with a possible debit of 300 infant deaths as the result of the operation. Dr. W. H. Welch spoke on the effects of vaccination during the incubation period of smallpox. Dr. August Martin delivered an address describing his vaginal operation of total extirpation of the uterus for cancer.

The *Tenth Congress*, held at Berlin, from August 4–9, 1890, was successful, as regards both numbers and scientific work. Some 7,000 members, representing thirty-one countries, were registered. Virchow was unanimously elected president. The principal feature of the Congress was the address of Koch, in which he announced his discovery of tuberculin, by means of which he had succeeded in immunizing guinea-pigs against tuberculosis, and also in arresting the growth and multiplication of the tubercle bacillus after inoculation. Lister reviewed the theories of immunity, dwelling on Metchnikoff's theory of phagocytosis, and expressed himself a firm believer in antisepsis as against asepsis. Professor Bouchard propounded a theory explanatory of immunity and infection. Professor von Bergmann gave an address on his aseptic methods, and Billroth presented his statistics, for the ten years under antiseptic methods, of the results obtained in resection of the stomach and intestines.

The *Eleventh Congress* was held at Rome from March 29 to April 6, 1894, under the presidency of Guido Baccelli. Forty-two nations were represented, and the number of scientific bodies which sent delegates was 434. The number of delegates invited was 817. The total registered membership of the Congress was over 7,600. The work of the Congress was divided into nineteen sections. Addresses were delivered at the general sessions by Virchow, A. Jacobi, Babes, Michael Foster, and Laache.

The *Twelfth Congress* was held from August 19–26, 1897, at Moscow, under the presidency of Professor Sklifossovsky. To commemorate the meeting the city of Moscow founded a research prize of 5,000 francs ($1,000) for the congresses in perpetuity. The prize is awarded to that person who in the interval since the preceding Congress has done the medical work deemed of the greatest benefit to humanity. The membership of the Congress was about 7,300. At this meeting Virchow reaffirmed his belief that the grand truth of unbroken cellular succession would never be overthrown. The diagnostic and therapeutic value of serums was discussed. The first Moscow prize was awarded to M. Henri Dunant for his organization of the International Red Cross Society. The number of sections was now twenty-one. The number of communications and papers presented reached 902.

The *Thirteenth Congress* held at Paris, from August 2–7, 1900, had a membership of over 6,000. Professor Lannelongue was elected president. At the opening session in the Salles des Fêtes, Lannelongue's address emphasized the value of international medical congresses in promoting international intercourse, breaking down prejudice, and cementing the bonds of a common humanity. Virchow spoke on traumatism and infection. Pavlov presented a paper on experimental therapy as a new and extremely fecund method of physiological research. Jacobi of New York spoke on medicine and physicians in the United States. Ehrlich spoke on his theory of the action of toxins. The Moscow prize was awarded to Professor Ramon y Cajal for his great work on the nervous elements. The work of the Congress was divided among seventeen sections. At this meeting another prize was founded, of the value of 3,000 francs ($600), to be awarded by a special committee at each Congress for a discovery or a collection of original works bearing upon medicine, surgery, obstetrics, or the

anatomical or biological sciences in their application to medical science.

The *Fourteenth Congress* was held in Madrid, April 23–30, 1903, under the patronage of King Alfonso and the Queen Mother. Professor Calleja y Sanchez was president. The subject of his address at the inaugural session was "The Progress of Medical Science." The attendance at this Congress was over 5,000, representing forty-six countries. The general addresses were by Arthur Thomson on anthropology, Coni on the campaign against tuberculosis in Latin America, Waldeyer on phylogenetic theories and Darwinism, Laache on reciprocity in pathology, Maragliano on immunization against tuberculosis, Brouardel on food adulteration, Fernandez on ocular affection in the tropics, Carracido on polypharmacy, Ramon y Cajal on the plan and construction of the thalamus, and Rolin on prophylactic and therapeutic indications in tuberculosis. The Moscow prize was awarded to Professor Metchnikoff for his researches on phagocytosis, and the Paris prize to Professor Grassi for his researches on malaria. The scientific work was divided among sixteen sections.

The *Fifteenth Congress* was held in Lisbon, April 19–26, 1906, under the presidency of Professor Costa Alemão, who reviewed in his address the rapid strides that medicine had made since the Madrid Congress three years before. Brissaud delivered an address on infantilism, Hansemann on the significance of domestication of animals in relation to disease, Crocq on the mechanism of the reflexes, and Senn on cancer.

The *Sixteenth Congress* was held at Budapest, August 26 to September 4, 1909, under the presidency of Baron Calman Müller. The scientific work was divided between 21 sections. The foreign members numbered 1,994, a larger proportional representation from distant countries than at any previous Congress. At the general session Professor Guido Baccelli of Rome delivered an address upon the intravenous administration of drugs; Dr. Bashford of London presented an address upon cancer, and Dr. R. Kutner of Berlin one on post-graduate study. The Moscow prize was awarded to Professor Bordet of Ghent, and the Paris prize to Professor Hertwig of Berlin. At the conclusion of this Congress the committee had a balance in the treasury of 20,000 Kronen ($4,000), and it was decided to invest this sum and devote the interest to a prize (called the Hungary Prize) of 3,000 Kronen ($600) to be awarded at each succeeding Congress for the best work, published in the intervening period, relating to medicine or the allied sciences. It was decided to lengthen the interval between the Congresses to four years. Originally it was two years, but after the Seventh Congress was made three years.

The *Seventeenth Congress* met in London, August 6–12, 1913, under the presidency of Sir Thomas Barlow. The membership exceeded 7,000. There were six general sessions besides daily meetings of twenty-six sections. The address in medicine was delivered by Professor Chauffard of Paris, in surgery by Professor Harvey Cushing of Boston, in pathology by Professor Ehrlich of Frankfort a. M., in heredity by Professor W. Bateson of Cambridge, and in public health by Mr. John Burns. The Moscow prize was awarded to Prof. Charles Richet of Paris for his work on anaphylaxis; the Paris prize to Prof. A. v. Wassermann of Berlin for his work on experimental therapy and immunity; and the Hungary prize to Sir Almroth E. Wright of London for his work in vaccine therapy. A resolution was adopted calling upon the governments of all the countries represented at the Congress to institute measures designed to restrict the spread of syphilis. The governments of countries in the far east were urged to prohibit the use of polished rice by the natives, in the hope of thereby overcoming beriberi, and they were also asked to abolish quarantine against this disease. A resolution was also passed changing the name Malta fever to undulant fever. It was voted to hold the next Congress in 1917 in Munich.

At the Internatinal Medical Congress at Budapest in 1909, the idea was discussed of coordinating all the special Congresses. The latter had been in existence for more than a quarter century, yet no movement of this sort had been seriously proposed. Accordingly at this Congress was instituted a permanent committee for the coordination of the special Congresses with headquarters at The Hague. These Congresses include, however, much more than the purely medical subjects. In order to trace the international movement in all its ramifications one may consult the works of Eijkmann entitled Internationalisme médical (1910) and Internationalisme scientifique (1911), both published at The Hague, Holland. Eijkmann's work serves well to fill up certain gaps in our knowledge. Thus strictly speaking there has never been an International Congress of anatomy worthy of the name. Prof. Nicolas of Paris attempted to consolidate five bodies of anatomists representing Great Britain, Germany, France, America, and Italy. Two meetings have been held—at Geneva, in 1905 and at Brussels, in 1910. A third should be held in 1915. This body thus far does not represent a true international congress. In addition, a "Central Committee for Brain Studies," was established at Amsterdam in 1909, in connection with an Institute. Waldeyer is president. Their plans have been made but no reports are mentioned.

Under *Pathology* may be mentioned only special Congresses like those on Cancer and Tuberculosis. In Sept., 1906 a Congress on Pellagra was held at Milan under the presidency of Prof. Bertarelli of Tunis. It did not apparently come up to international requirements.

Under *Pediatrics* there has been no separate international Congress, but several have been organized in the interest of infants. There is an International Union for the Protection of Infants. This association first founded the Congrès de Gouttes de Lait which met at Paris in 1905 and Brussels in 1907. The Third Congress was held at Berlin, 1911, the German title being Internationaler Kongress der Säuglingsschütz. An International Congress having for its aim the supervision of milk production has held five meetings as follows: Brussels, 1903; Paris, 1905; Hague, 1907; Budapest, 1909, Stockholm, 1911.

The following are the dates and places of meeting of a number of other Congresses on various subjects.

Hygiene and Demography.—The International Congress of Hygiene or of Hygiene and Demography was believed for years to date from a meeting held in Paris in 1878. It is really, however, a quarter of a century older than that.

The *First Congress*, or what later came to be recognized as such, was held in Brussels, September 20-22, 1852.

The *Second Congress* was held at Brussels twenty-four years later in 1876. It bore no relation to the first, and it is also noted that no permanent organization was formed. The occasion of this meeting was that in that year Brussels gave an Exposition of Hygiene and Public Safety. The Congress proved a most important one and two large volumes were required for publishing the transactions. Delegates were present from fifteen countries. The president was Vervoort. The United States sent no delegates.

The *Third Congress* (long known as the first) was held in Paris, August 1–10, 1878, in the year of a Universal Exposition. This meeting was regarded in some quarters as a logical successor of the Brussels Congress, but it was not until the Paris Congress

that a permanent organization was formed. The president was A. Gubler. Twenty-three countries sent delegates. The United States was represented by thirty-two members.

The *Fourth Congress* was held at Tunis, September, 1880.

The *Fifth Congress* was held at Geneva, September 4–9, 1882. President H. C. Lumbard. The Congress, hitherto known as the Congress of Hygiene now became officially the Congress of Hygiene and Demography.

The *Sixth Congress* was held at The Hague, August 21–27, 1884.

The *Seventh Congress* was held at Vienna, September 26 to October 2, 1887. President, Franz Ritter von Schneider.

The *Eighth Congress* was held at Paris, August 4–10, 1889.

The *Ninth Congress* was held in London, August 10–17, 1891, under the presidency of Sir Joseph Fayrer. The work was done in twelve sections. Twenty-eight countries were represented by delegates to the number of 1,132. The guests numbered over 3,000. The full membership of the Congress was 2,483. The sections comprised: 1. Preventive medicine. 2. Bacteriology. 3. Animal Diseases Attacking Man. 4. Infancy, Childhood, and School Life. 5. Chemistry and Physics of Hygiene. 6. Architecture of Hygiene. 7. Engineering of Hygiene. 8. Naval and Military Hygiene. 9. State Hygiene. 10. Demography. 11. Demography and Hygiene in India. 12. Municipal Demography and Hygiene. The transactions of this Congress were published in fourteen volumes.

The *Tenth Congress* was held at Budapest, September 1–9, 1894. President, Josef Fodor. The tranactions in seven volumes were bilingual—French and Hungarian. Nineteen countries sent delegates and between 500 and 600 papers were sent in.

The *Eleventh Congress* was held at Madrid, April 10–17, 1898. The president was Dr. Calleja y Sanchez. The work was done in thirteen sections of which three were devoted to demography. Sixteen countries only were represented.

The *Twelfth Congress* was held at Paris, August 10–17, 1900; president Brouardel. The number of sections was reduced to nine, there being but one on demography. The transactions were published in a single volume.

The *Thirteenth Congress* was held at Brussels, September 2–8, 1903, under the presidency of Emile Beco, and appears to have been a great success, equalling that of London in 1891. Delegates to the number of 500 represented thirty-five countries. The membership now amounted to over 1,200. The transactions filled nine good-sized volumes.

The *Fourteenth Congress* was held at Berlin, September 23–29, 1908. The sections numbered eight—Bacteriology, Dietetics, Schools, Trades, Contagious Diseases, Dwellings, Traffic, Military and Naval. The membership of this Congress was 3,000. The president was Prof. Bumm of Berlin. The transactions were published in four volumes.

The *Fifteenth Congress* was held at Washington, D. C., Sept., 1912. The president was Max Rubner. Over 3,500 delegates and guests attended the Congress, of whom about 500 were from abroad.

In addition to the International Congress of Hygiene and Demography a separate body unrelated in every respect to the latter came into existence in 1904 with the title of

Hygiene of Dwellings.—The *First Congress*, held at Paris in 1904 was the outgrowth of the French Society of Hygiene, and was a feature of the International Exposition of Hygiene, held at the same time. It was to a much less extent a medical body than the original International Congress, and was made up largely of architects and engineers. The president, Senator Paul Strauss, was not a medical man.

In the *Second Congress* held at Geneva, 1906, under the presidency of Henri Fazy, delegates from twenty-four countries were present. Sectional work was under way and twelve sections had been formed. The sections comprised City Homes for the Middle Classes, Tenements for the Workers, Rural Dwellings, Furnished-room Houses and Hotels, Disposal of Excreta, Military Posts, Offices and Factories, Schools, Trains and Sleeping-cars, Decoration, etc.

The *Third Congress* was held at Dresden in 1911, under President Renk. Twenty countries were represented by delegates. The number of sections was reduced from twelve to nine by condensation.

Surgery.—The *First Congress* of the International Society of Surgery was held at Brussels, Sept., 1905. The society was organized at Brussels in 1902. The official languages are French, German, and English. Brussels was also appointed the place of meeting for all the Congresses. The president of the First Congress (1905) was Kocher of Berne. An International committee was formed with Roswell Park representing the U. S. A. Delegates were appointed for 1905–08 from twenty-three countries. There were three from each country the U. S. being represented by R. Park, Warren (Boston) and McArthur (Chicago). The list of members was large. The chief subjects for open discussion were surgery of the liver, anesthesia, surgery of the spine, hernias, peritonitis, surgical diseases of the kidneys.

The *Second Congress* was held at Brussels in 1908. Czerny of Heidelberg was president. The three American representatives were as before. There appear to have been neither sections nor approved subjects for discussion. But a large portion of the work of the congress was devoted to cancer. Some of the subjects of the First Congress were continued.

The *Third Congress*, also held in Brussels in 1911 under the presidency of Lannelongue, dealt very largely with surgery of the chest and abdomen. The representatives of the permanent organization were as before. There is no desire to add to the membership which amounts to 500 and is naturally meant to comprise the leading surgeons of the world. The United States is represented by upwards of sixty men, nearly all clinical professors in the medical school.

The *Fourth Congress* is announced to be held in New York, April 14–18, 1914, under the presidency of Prof. A. Depage of Brussels.

Gynecology and Obstetrics.—The *First Congress* assembled in Brussels, September 14–17, 1892. The inception of the movement is not stated, but it evidently was inspired by Belgians, and apparently by the Belgian Society of Gynecology and Obstetrics. At the opening session a brief address of welcome by the president, Kufferath, appears to show that the Congress was an experiment in which other high officials joined with the leaders of the medical faculty in inviting the leading gynecologists of the world to meet at Brussels, for the purpose of discussing incidentally three burning questions of the day, to wit, Pelvic Suppurations, Extrauterine Pregnancy, and Placenta Previa. All societies dealing with these subjects sent delegates. The United States societies were represented by Engelmann, Marcy, Price, Etheridge, Edebohls, and others. In addition numerous honorary presidents were selected from eighteen countries. Those from the United States included Battey, Byford, Emmet, Fenger, Thomas, Goodell, Kelly, Lusk, Parvin, and Reamy. When it is borne in mind that equally illustrious men represented the other countries the superior character of this Congress over those devoted to general subjects readily appears. A permanent Congress was established by fifty-five members, among whom we note the following additional Americans—Baker (Harvard),

Boldt, Dudley, Henrotin, J. B. Murphy, Mary Putnam-Jacobi, Skene, J. C. Wood, and others. The entire membership was about 300.

The *Second Congress* met at Geneva, September 1–5, 1896. The two subjects gynecology and obstetrics were now quite dissociated, each having its own officers. The president of the gynecological section was Reverdin. The representation by delegates and honorary presidents was quite similar to that of the First Congress. Among the Americans not present at the latter were Chadwick, Taber Johnson, Polk, Reed, Wylie, Senn, Sutton, and others. Under the names of "founders of the Congress" we note E. P. Davis, E. Dudley, Goldspohn, J. D. Emmet, Janvrin, Jewett, Krug, Mann, Montgomery, Noble, Penrose, Pryor, and numerous others. The participation of America in these Congresses was most striking. The total attendance and membership were naturally small, as becomes an "all star aggregation." The subjects prearranged for discussion were as follows: Treatment of Pelvic Suppurations, and Surgical Treatment of Retrodeviations of the Uterus. The obstetric division of the second session of the Congress was presided over by Laroyenne and Morisani. The chief subject discussed was contracted pelvis.

The *Third Congress*, held at Amsterdam, August 8–12, 1899, under the presidency of H. Treub, revoked the separation of gynecology from obstetrics. Honorary presidents were chosen from eighteen countries, and delegates from six countries and many gynecological and other societies. Leading Americans appeared under all these heads, and they well represented in numbers, but many who took part in the first two Congresses were absent from this. Some well-known men attended who had not done so before, as Gordon of Maine, Fry and King of Washington, Vander Veer of Albany. The other countries were represented by their best men as a rule, although we miss the names of the great German specialists.

The *Fourth Congress* was held at Rome, September 15–21, 1902. Pasquali was president. The attendance was more evenly distributed than at the previous Congress, the papers were up to the mark, and the transactions appeared in one compact volume of about 1,000 pages. Eight years elapsed before the next Congress was held.

The *Fifth Congress* was held in St. Petersburg, September 22–28, 1910, under the presidency of Professor Dmitri de Ott. The number of visitors registered was 783 of whom 654 were members. A few leaders among the gynecologists of other countries, notably presidents of prominent societies were present as honorary presidents, etc. Russian and French were the official languages. Doederlein was the acting president, but each section was presided over by one of the other honorary presidents. Wetherill was the only honorary vice-president from America.

The *Sixth Congress* was held in Berlin, September 9–13, 1912, under the presidency of Professor Bumm of Berlin. The two principal subjects discussed at this meeting were: 1. Reaction of the peritoneum to surgical interference and the best method of controlling it; 2. Surgical treatment of uterine hemorrhage in puerperal cases.

The *Seventh Congress* is to be held in New York under the presidency of J. Riddle Goffe.

Dermatology.—The *First Congress* was held at Paris, August 5–10, 1889 under the presidency of Ricord. It comprised both dermatology and syphilography. In this first meeting the activities were limited to a discussion of a number of problematical diseases.

The *Second Congress* held in Vienna, September 5–10, 1892, was under the presidency of Hardy of Paris. The word syphilography does not enter into the name of the congress. The existence at the time of cholera along the Danube appears to have exerted an unfavorable action on the attendance at the Congress on account of the quarantines.

The *Third Congress* was held in London, August 4–8, 1896, under the presidency of Mr. Jonathan Hutchinson. There were over 300 members present.

The *Fourth Congress* held in Paris, August 2–9, 1900, once more assumed the joint title dermatology and syphilography. The president was Besnier. It was a truly representative body, and the attendance was good.

The *Fifth Congress* was held at Berlin, September 12–17, 1904 under the presidency of Lesser of Berlin. In this session reports from twenty-six countries were made by representative men on the subject of leprosy, amounting to a veritable conference on this disease.

The *Sixth Congress* was held at New York, September, 9-14, 1907. The president was J. C. White of Boston. The representation outside of the United States was relatively small, but prominent men from all over the world attended.

The *Seventh Congress* was held in Rome, in April, 1912, under the presidency of Bertarelli of Milan.

Leprosy.—A Congress for the study of leprosy was held in Berlin in October, 1897. Over 150 delegates and members participated, and the number of communities represented was large. Virchow was made president because, as Lassar said in his opening address, "all of us have studied under him and because he discovered the lepra cell." Probably for a meeting of this size more distinguished representative men were present than in any similar one on any subject. A Second Congress was held at Berlin, in 1909, under the presidency of Armauer Hansen.

Ophthalmology.—The *First Congress*, held in Brussels, September 13–16, 1857, was not at first spoken of as International but is now regarded as the first of the series. The president was Fallot, who was also president of the Royal Academy of Medicine of Belgium.

The *Second Congress* was held in Paris, September 30 to October 3, 1862, just after the formation of the Société universelle d'ophthalmologie. There were a number of foreign eye specialists visiting Paris at time and as a result a congress was formed. These men, however, were not modern ophthalmologists but surgeons—Valentine Mott, Pancoast, Sr., et al.—men who had done much eye work without being specialists. A permanent organization was formed. Williams of Cincinnati, an American pioneer oculist, was a member. Von Graefe was president.

The *Third Congress* (known for a time as the second) met at Paris, August 12–14, 1867. The representation in general was good, but that from the United States was small—few oculists of wide repute being present.

The *Fourth Congress* would have been held at Berlin, 1871, but as von Graefe died it was held in London, August 1–3, 1872, As usual London put life into this international congress. The best men were included in the delegates. From the United States came Agnew, Knapp, Roosa, Noyes, Norris, Williams of Cincinnati, and Williams of Boston.

The *Fifth Congress* was held at New York, 1876, under the presidency of E. Williams of Cincinnati. But few foreign delegates were in attendance.

The *Sixth Congress* was held in Milan, Sept., 1880 and had a notable predominance of Italians. President Quaglino.

The *Seventh Congress* was held August 8–11, 1888, at Heidelberg. Becker of Heidelberg was president. The American attendance was somewhat light.

The *Eight Congress* was held in Edinburgh, August, 1894. A list of papers read shows a number of American authors of wide reputation (Knapp, Noyes, S. W.

Burnea, Theobald, Stevens, Chisholm, Gould, and Moore). The president was Argyll Robertson.

The *Ninth Congress* was held at Utrecht, August 14–18, 1899. *Snellen* of that city was president. The bulk of the attendance came from the low countries and contiguous countries.

The *Tenth Congress* was held at Lucerne, September 13–17, 1904. The president was Dufour, succeeding the first nominee Pfluger of Berne, who had died in the interim. Knapp, Weeks, Howe, Bruns, and Duane presented papers.

The *Eleventh Congress* was held at Naples, April 2–7, 1909. Delapersonne of Paris was president.

Laryngology.—The *First Congress* was organized by Dr. Labus of Milan and held at Milan, September 2–5, 1880. The incentive seems to have been the success of the Congrésses of Ophthalmology and Otology. The president was naturally Labus himself. Distinguished specialists from a respectable number of countries took an active part in the proceedings and the United States was represented by Elsberg of New York, Porter of St. Louis, and others. The chief topic of discussion was Tuberculosis of the Larynx.

The *Second Congress* held at Vienna in 1908 was known as the Laryngo-Rhinological Congress. The president was Chiari. Numerous delegates were sent from Governments, Societies, Universities, etc. This Congress was really a meeting held in honor of Türck and Czermak.

The *Third Congress* was held in Berlin in September, 1911, under the presidency of B. Fränkel. There were 147 German and 292 foreign delegates, sent from twenty-seven countries. The United States sent forty-one of these and Great Britain twenty-seven. An important paper was read by Chevalier Jackson on esophagoscopy, which subject together with gastroscopy, seems to have been brought with bronchoscopy into the field of laryngology.

Otology.—In anticipation of the centennial exposition of 1876 the American Otological Society organized the International Otological Society. The meeting was actually held in New York City in September, 1876, with St. John Roosa as president. Numerous foreign delegates were invited to join the International Society but less than half a dozen appeared to have availed themselves of the offer.

The *Second Congress* was held at Milan, September 6–9, 1880. The meeting was in theory at least the legitimate successor of the first, although this was chiefly American while the second was largely Italian. The president was Sapolini of Milan.

The *Third Congress* was held at Basle, September 1–4, 1884, under the presidency of Burckhardt-Merian. An attempt was made to divide the work into sections—anatomy, physiology, etc. The representation from the United States, Great Britain, Italy, and some other countries was very small.

The *Fourth Congress* was held in Brussels, September 10–14, 1889, under the presidency of Delstanche. But few Americans were in attendance. The whole membership was not much over one hundred.

The *Fifth Congress* was not held until September 23–26, 1895 at Florence. The president was Grazzi. Eight American representatives were present, but they submitted no papers.

The *Sixth Congress* was held in London, August 8–12, 1899, under the presidency of Urban Pritchard, who had been one of the most active members of the International Society in all of the congresses. There were now thirteen countries represented; but for some unknown reason there were but few delegates from France and Germany, despite the high development of otology in these countries. About one-half the participants were British.

The *Seventh Congress* was held in Bordeaux, August 1–4, 1904, under the presidency of E. J. Moure. For the first time in the history of the congresses there seems to have been a proportionate representation of each country, no important foreign land showing neglect in this respect.

The *Eighth Congress* after a long period of latency, was substituted for the Section of Otology of the International Medical Congress, held at Budapest, August 23 to September 9, 1909.

The *Ninth Congress* was held at Boston, in August, 1912. The greater number of participants were Americans. There were all told 213 members and 197 guests. The president was C. J. Blake.

Otology and Laryngology. The sole meeting of this Congress occurred in Paris, September 16–21, 1889. The president was Duplay, and the membership was very largely the same as that of the International Otological Society. Of the Americans Delavan and Turnbull read papers. There seems to have been no need of this International Congress, and it was not repeated.

Psychology.—The *First Congress* was held in Paris, 1890, under the auspices of the Société de Psychologie Physiologique de Paris. Prof. Charcot was president, and so-called "committees of patronage" were chosen from other nations, twelve in number. America was represented by W. James. Among patrons from other countries we note such names as Helmholtz, Wundt, Ribot, Janet, Galton, H. Jackson, Exner, Meynert, Lombroso, Mosso, Setschenoff, and Tigerstedt. Subjects discussed jointly were heredity and hypnosis, along with isolated papers on psychology.

This Congress appears to have had no connection with another held under the same name in Paris, August 6–12, 1889, and sometimes called the first Congress on Psychology. Ribot was president.

The *Second Congress* was held in London, August 2–5, 1892, under the presidency of Sidgwick, who proposed to name the body the "Congress for Experimental Psychology."

The *Third Congress* was held in Munich, August 4–7, 1896, and was known simply as the Congress of Psychology. There was a permanent organization with committee members from the leading countries in Europe and the United States. The titles of the Sections were Psychophysiology, Psychology of the Normal Man, and Psychopathology. These were freely subdivided. The membership of the Congress was between 300 and 400. The vast number of subjects discussed, differing so much among themselves, makes a digest impossible, but hypnotism and suggestion were much in evidence. The Congress had two active presidents, Stumpf of Berlin, and Lipps of Munich.

The *Fourth Congress* was held at Paris, August 20–25, 1900. Ribot was president.

The *Fifth Congress* was held at Rome, April 26-30, 1905 under the presidency of Sergi, the distinguished anthropologist.

Neurology, Psychiatry, Medical Electricity, and Hypnology.—This Congress, the only one held under this name, had its session at Brussels, in September, 1897. It was organized by a committee headed by Crocq, Jr., of Brussels and drawn from the leading authorities of the principal cities of the world. The only U. S. representative was Donaldson of Chicago. The executive president was Prof. Verriest of Louvain. The membership was rather limited and chiefly localized to the continent, especially those portions nearest Belgium. The United States and Great Britain were barely represented.

This Congress was not repeated. Ten years later the International Congress of Psychiatry, Neurology, Psychology, etc., continued its activity.

*Psychiatry, Neurology, Psychology and Assistance of the Insane.*—The First International Congress on these combined subjects was held at Amsterdam, in September, 1907. In the preface of the Transactions

it is stated that this Congress might take over the work of earlier International Congresses, each of which had had several meetings. The Congresses in question were, respectively, the Congress of Psychology, a meeting of which was to be held in Geneva, 1909; and the Congress of Assistance of Insane, the next meeting of which was to be held at Vienna in the same year. At Brussels in 1898 there was also held an International Congress on Psychiatry, Neurology, and Medical Electricity. The present Congress was an avowed attempt to consolidate and continue the work of these older congresses, and has since been called the Second Congress on Neurology and Psychiatry.

The active president of this Congress was G. Jelgersma of Leyden. Committees of International Propaganda were appointed from thirty countries, the members comprising many psychologists as well as physicians and alienists. Many countries and Societies also sent delegates so that a large and uniform representation was available. The Congress was divided into three sections, each with its proper officers, who were practically all from the Netherlands. These sections were as follows: (1) Psychiatry and Neurology, (2) Psychology and Psychophysics, and (3) Assistance to the Insane.

*Neurology and Psychiatry.*—At Ghent, August 20–26, 1913, was held what was designated the Third Congress of Neurology and Psychiatry. It was in fact a combination of the two congresses above mentioned. It was held under the dual presidency of Dr. Crocq, Professor of the University of Brussels and of Dr. Glorieux, Inspector General of the Belgian Asylums and Colonies for the Insane. About 150 members were in attendance.

Medical Electrology and Radiology.—The *First Congress* of this name and scope was held at Paris in the summer of 1900, under the presidency of G. Weiss. The initiative came from the Société française d'électrothérapie, during its annual session in 1899. Among the organizers are to be noted such well-known names as Apostoli and Oudin. There were about 175 members present at the session. The subject of Electrology was divided into four sections: (1) Electrophysiology; (2) Electrotherapy (subdivided according to disease groups); (3) Electrodiagnosis, and (4) Electrotechnics. Radiology was divided into Diagnosis, Therapeutics, and Technics.

The *Second Congress* was held at Berne, September 1–6, 1903. The president was Dubois, and the various patrons of the Congress were chiefly eminent local clinicians who made much practical use of electricity and radiology. The membership of this Congress was much smaller than that of its predecessor. The sectional arrangement of the first congress was done away with and in its place there were general discussions on five subjects: Electrodiagnosis, Accidents from *x*-rays, Deep radiography, Electrical surgery, and Death and accidents from industrial electricity.

The *Third Congress* was held in Milan, September 5–9, 1906.

The *Fourth Congress* assembled in Amsterdam, September 1–5, 1908, under the presidency of J. K. A. Wertheim Salomonson. Einthoven's string dynamometer was demonstrated by Boruttau of Berlin, Einthoven himself being unable to be present.

The *Fifth Congress* met in Barcelona, September 13–18, 1910.

Radiology and Ionization.—This Congress was held in 1905 at Liège as the first under the name. It appeared to stand in no relationship whatever with the International Congress of Medical Electrology and Radiology. Dr. H. Kuborn was the executive president.

A Congress of Radiology and Electricity met in Brussels, September 15–17, 1910.

Cancer.—The *First Congress* for the Study of Cancer was held in Heidelberg and Frankfort in 1906. The Congress appears to have been the outcome of the Central Committee for Cancer Research established in Berlin, 1900. The participants from fifteen countries numbered 412 not including guests of honor. The president was Prof. Czerny.

The *Second Conference* was held Oct. 1–5, 1910, in Paris. Czerny again appeared as president. No less than twenty-three countries were represented by delegates.

The *Third Congress* was held in Brussels, August 1–5, 1913, under the presidency of Professor Debaisieux of Louvain. The principal discussion was on the radiotherapy of cancer.

The *Fourth Conference* is announced to take place in Copenhagen in 1916.

School Hygiene.—The *First Congress*, which owed its inception to the suggestion and labors of Dr. H. Griessbach, was held at Nuremberg, April 4–9, 1904, under the presidency of Dr. Griessbach. The object of these congresses is stated to be to direct the attention of existing authorities to the importance of, and the practical means of attaining the most nearly perfect results in, the physical and mental wellbeing of school children; to direct attention to the hygiene of the teachers themselves, and to give an opportunity to those specially interested in the wellbeing of the young to study and appreciate the means whereby this object can best be obtained.

The *Second Congress* assembled in London, August 5–10, 1907, under the presidency of Sir Lauder Brunton.

The *Third Congress* was held at Paris, August 2–7, 1910, and appears to have been remarkably successful. The president was A. Mathieu. Patrons from twenty-five countries were present, including for America, President Butler of Columbia College, Stanley Hall, L. H. Gulick, and others. The membership also comprised many American physicians and educators. Among the leading subjects discussed were anomalous children, anthropometry, care of teeth, handwriting, physical culture, sexual education, antialcoholic propaganda, medical inspection, sports and games, parasitic diseases, vision, school work, manual training, and many more of equal interest.

The *Fourth Congress* was held August 25 to 30, at Buffalo, N. Y., under the presidency of Dr. Charles W. Eliot, President Emeritus of Harvard University. The Congress was divided into three sections, viz., (1) The hygiene of school buildings, grounds, material equipment, and up-keep; (2) the hygiene of school administration, curriculum, and schedule; and (3) medical, hygienic, and sanitary supervision in schools.

Tuberculosis—The International Congresses on Tuberculosis have been quite irregular in their dates of meeting as well as varied in their management.

An early series of four congresses was held in Paris under the title: "Congrès pour l'Etude de la Tuberculose chez Hommes et chez les Animaux." The *First Congress* was held July 25–31, 1888, under the presidency of Prof. Chauveau; the *Second*, July 27–August 2, 1891, under the presidency of Prof. Villemin; the *Third*, July 27–August 2, 1893, under the presidency of Prof. Verneuil; and the *Fourth*, July 27–August 3, 1898, under the presidency of Prof. Nocard;

These four congresses were really national rather than international in character, although they were attended by some foreigners; and the same may perhaps be said of the *Fifth Congress* held May 24 and 25, 1899, in Berlin, under the title, "Kongress zur Bekämpfung der Tuberculose als Volkskrankheit." The presidents were the Duke of Ratibor and Prof. v. Leyden.

The *Sixth Congress* was held in London, July 22–26, 1901, under the multiple presidency of the Duke of

Cambridge, Lord Lister, Dr. Henry Chaplin, Lord Spencer, and Lord Derby. It was at this Congress that Koch startled the medical world with the assertion that animal tuberculosis was a negligible factor, so far as human health and life were concerned, since, as he contended, the bovine bacillus was not pathogenic for man.

The *Seventh Congress* met in Paris, October 2–7, 1905, under the presidency of Héraud.

The *Eighth Congress* was held September 21–October 10, 1908, in Washington, under the presidency of Koch, Landouzy, Theodore Williams, and Trudeau. Through an error in count or because some of the earlier congresses were not regarded as international, this was called the Sixth International Congress in some of the official notices.

The *Ninth Congress* was held in Rome, April 14–20, 1912, under the presidency of Prof. Baccelli.

Other congresses for the study of tuberculosis have been held from time to time, as in Naples in 1900, but they have been chiefly local in character and are not counted in the series of International Congresses.

*International Tuberculosis Conference.*—During the meeting of the London Congress in 1901 there was organized an International Tuberculosis Conference, the meetings of which have been held annually, except in 1911, when, the International Congress having been postponed from September 1911 to April 1912 on account of the prevalence of cholera, the date of the Conference was also changed. In 1913 the Conference was held in Berlin, October 22–25.

Medical Press.—The First International Congress of the Medical Press was held in Paris, July 26–28, 1900, under the presidency of Professor Cornil, Virchow being the honorary president. The Second Congress was held in Madrid, April 20, 1903, under the presidency of Dr. Carlos M. Cortezo. The Third Congress was held in Budapest, August 27, 28, 1909. In the absence of the president, Dr. Posner of Berlin, the chair was taken by Dr. Déjace of Belgium. The Fourth Congress was held in London, August 5 and 6, 1913; Dr. Lucas Championnière, presided.

In addition to these Congresses, held at the same time and in the same place as the International Medical Congresses, there is an International Association of the Medical Press which meets yearly.

Life Insurance Medical Officers.—The First International Congress of Medical Officers of Life Insurance Companies was held at Brussels, September 25–28, 1899, under the presidency of Dr. Vleminckx. The Second Congress was held at Amsterdam, September 23–25, 1901, Dr. Van Geuns presiding. The Third Congress met in Paris, May 25–28, 1903. The Fourth Congress was held in Berlin, September 10–15, 1906, under the presidency of Dr. Unverricht. It was there announced that a fifth congress would assemble in Vienna, but no report of any such meeting having been held is to be found.

Tropical Medicine.—The Far Eastern Association of Tropical Medicine is truly international, though not universal in its membership. The Association is an outgrowth of the Philippine Islands Medical Association and was organized at an annual meeting of the latter in 1908, most of the oriental governments being represented by delegates at that meeting. The Philippine Government gave the new Association its cordial support, both moral and financial. The Association is supposed to meet biennially.

The *First Congress* was held in Manila, March 5–14, 1910, under the presidency of the late Dr. Paul C. Freer. Eighteen oriental nations or colonies were represented.

The *Second Congress* was held at Hongkong, June 20–27, 1912, under the presidency of Dr. J. Mitford Atkinson, of that city.

The *Third Congress* was held at Saigon, November 8–15,1913, under the Presidency of Dr. Clarac, Inspector of the Sanitary Service of the Colonial Troops.

Stomatology.—This Congress includes four sections, namely: 1. Professional legislation and organization. 2. Instruction. 3. Public and private buccal hygiene. 4. International stomatological literature and bibliography. The first Congress was held August 6–7, 1907, in Paris. The second, August 29 to September 2, 1909, at Budapest, at the same time as the Medical Congress; the third in 1911, in Paris at the same time as the French Stomatological Congress.

Dentistry.—These Congresses are organized by the International Dental Federation, which has held annual sessions since 1900, before that time meeting only on the occasion of the Congress. The following congresses have been held: The first from September 2–7, 1889, in Paris; the second, August 14–19, 1893, in Chicago; the third, August 8–14, 1900, in Paris; the fourth, August 29 to September 23, 1904, in St. Louis; the fifth, August 23–28, 1909, in Berlin; and a sixth will be held August 3–18, 1914, in London.

Pharmacy.—The following Congresses have been held: the first, September 15–17, 1865, in Brunswick; the second, August 11–14, 1867, in Paris; the third, September 9–11, 1869, in Vienna; the fourth, August, 1874, in St. Petersburg; the fifth, August 1–3, 1881, in London; the sixth, August 31 to September 6, 1885, in Brussels; the seventh, August 21–23, 1893, in Chicago; the eighth, August 14–19, 1897, in Brussels; the ninth, September 2–8, 1900, in Paris; the tenth, September 1–5, 1910, in Brussels.

Alimentary Hygiene and Rational Ailmentation for Man.—This Congress comprises the following sections: 1. Biological physics; 2. Biological and physiological chemistry; 3. Rational alimentation and dietetics. 4. Analytical chemistry, adulteration, and legislation. 5. Bacteriology, toxicology, and parasitology. The First Congress met, October 22–27, 1906, in Paris; the Second, October, 4–8, 1910, at Brussels.

Vegetarianism.—The Congress includes the following sections: 1. Vegetarianism and Hygiene, (*a*) Régime sufficient for normal nutrition. (*b*) Régime sufficient for functional hygiene, (*c*) Natural stimulants and vegetarian hygiene. 2. Therapeutic vegetarianism; (*a*) Vegetarian régime, physiological action, therapeutic deduction. (*b*) Vegetarian system and its hygienic and therapeutic applications. 3. Economical and social aspects of vegetarianism. 4. Moral aspect of vegetarianism. The First Congress was held, August 18–19, 1908, at Dresden; the second, October 15–16, 1909, at Manchester, and the third, June 10–12, 1910, at Brussels.

Against Alcoholism.—The connection between these congresses, the name of which has been subjected to some slight modifications, is maintained by a permanent Committee. The first Congress met August 4–11, 1894 at Brussels; the second, July 27 to August 5, 1896 in Paris; the third July 28 to August 2, 1898 in Vienna; the fourth, July 23–28, 1900 in Paris; the fifth, June 2–9, 1903 in Berlin; the sixth, April 26 to May 3, 1906 in Rome; the seventh, May 27 to June 2, 1909 in London; the eighth, September 11–16, 1911 at The Hague.

Another and older organization, called variously the League against the Abuse of Spirituous Liquors and the International Anti-alcoholic Congress, meets now once in two years. The first Congress was held Sept. 11–13, 1885 at Antwerp; the second, Sept. 8–11, 1887 at Zurich; the third, Sept. 3–5, 1890 at Christiania; the fourth, August 15–18, 1893 at The Hague; the fifth, August 20–22, 1895 at Basle; the sixth, August 30 to Sept. 3, 1897 at Brussels; the seventh, April 4–9, 1899 at Paris; the eighth, April 9–14, 1901 at Vienna; the ninth, April 14–19, 1903 at Bremen; the tenth, Sept. 11

–16, 1905 at Budapest, the eleventh, July 28 to Aug. 3, 1907 at Stockholm; the twelfth, July 18–24, 1909 at London; the thirteenth, 1911 at The Hague; the fourteenth, Sept. 21–25, 1913 at Milan.

It is announced that the fifteenth congress will be held at Atlantic City, N. J., in 1915.

Occupational Diseases.—The Congress includes the following sections: 1. Must the professional diseases be distinguished from the accidents of work? What would be their differential characteristics? 2. What is the actual medical equipment of mines, of factories, of manufactories, of workshops, of coal yards? 3. The present status of the fight against ankylostomiasis; 4. The eye and vision as related to professional maladies. 5. Work in compressed air. 6. Professional intoxications. The first Congress was held in 1906 at Milan; the second, September 10–14, 1910 at Brussels.

Homeopathy.—The following Congresses have been held: the first, June 26–30, 1877 in Philadelphia; the second, August 12–14, 1878 in Paris; the third, July 11–16, 1881 in London; the fourth, August 5, 1886 in Bâle; the fifth, August 21–23, 1889 in Paris; the sixth, May 29 to June 3, 1893 in Chicago; the seventh, August 4–12, 1895 in Hamburg; the eighth, August 3–8, 1896 in London; the ninth, July 18–21, 1900 in Paris; the tenth, September 10–15, 1906 in Atlantic City; the eleventh, August, 1913 at Ghent.

Physiotherapy.—The first Congress was held August 12–15, 1905 at Liège; the second, October 13–16, 1907 in Rome; and the third, March 29 to April 3, 1910 in Paris.

Hydrology, Climatology, and Geology.—There are four sections: 1. Medical hydrology. 2. Medical geology. 3. Climatology. 4. Therapy by physical agents. Congresses have been held as follows: The first Congress was held October 1–8, 1886 at Biarritz; the second, October 3–10, 1889 in Paris; the third, 1894, in Rome; the fourth, September 28 to Oct. 4, 1896 at Clermont-Ferrand; the fifth, September 25 to Oct. 3, 1898 at Liege; the sixth, September 29 to Oct. 3, 1902 at Grenoble; the seventh, October 10–18, 1905 in Venice; the eighth, April 4–10, 1909 in Algiers; the ninth, October 15–22, 1913 in Madrid.

Thalassotherapy.—The first Congress assembled in the year 1894 at Boulogne-sur-Mer; the second, August 27–31, 1895 at Ostend; the third, April 19–21, 1903 at Biarritz; the fourth, September 28–30, 1907 at Abazzia; the fifth, June 5–8, 1911 at Kolberg.

Accidents of Working Men.—The first Congress was held September 9–14, 1889 in Paris: the second, September 21–26, 1891 at Berne; the third, October 1–6, 1894 at Milan; the fourth, July 26–31, 1897 at Brussels; the fifth, June 25–29, 1900 in Paris; the sixth, June 17–24, 1902 at Düsseldorf; the seventh, September 17–23, 1905 in Vienna; the eighth, October 12–16, 1908 in Rome; the ninth, September 6–8, 1910 at The Hague.

Eugenics.—An Internatimal Congress of Eugenics, which was intended to be the first of a regular series of Congresses, was held in London, July 24–30, 1912, under the presidency of Major Leonard Darwin. The papers presented at the Congress were published in book form under the title, "Problems in Eugenics".

Amelioration of the Condition of the Blind.—The first Congress was held August 5–8, 1889, in Paris; the second, August 1–5, 1900, in Paris; the third, August 6–10, 1902, at Brussels; the fourth, October 7–11, 1908, in Vienna; the fifth, March 30 to April 3, 1909, at Naples.

Amelioration of the Condition of Deaf-Mutes.—The first Congress was held September 23–30, 1878, in Paris; the second, September 6–11, 1880, in Milan; the third, August 13–18, 1883, in Brussels; the fourth, August 6–8, 1900, in Paris; the fifth, August 20–22, 1905, in Liège.

Epilepsy.—The first congress was held September 2, 1909, in Budapest; the second, September, 1910, in Berlin.

Protection of Children.—The first Congress was held June 15–23, 1883, in Paris; the second, July 29 to August 3, 1895, at Bordeaux; the third, September 14–19, 1896, at Geneva; the fourth, July 15–18, 1902, in London.

Criminal Anthropology.—The first Congress was held November 16–23, 1885, at Rome; the second, August 10–17, 1889, in Paris; the third, August 3–17, 1892, at Brussels; the fourth, September 24–29, 1896, at Geneva; the fifth, September 14–19, 1901, at Amsterdam; the sixth, April 28 to May 3, 1906, at Turin; the seventh, October 9–13, 1911, at Cologne.

Physical Education.—The first Congress was held August 30 to Sept. 6, 1900, in Paris; the second, August 28 to Sept. 1, 1905, at Liège; the third, August 10–13, 1910, at Brussels.

Veterinary Medicine.—The work of these Congresses is done in five sections, viz,, 1. Public veterinary medicine and control of the alimentary materials. 2. Pathology and bacteriology. 3. Practical veterinary medicine. 4. Zootechnics and zootechnical hygiene. 5. Tropical maladies. The first Congress, July 14–18, 1863, Hamburg; the second, August 21–26, 1865, Vienna; the third, September 2–7, 1867, Zurich; the fourth, September 10–16, 1883, Brussels; the fifth, September 2–8, 1889, Paris; the sixth, September 16–21, 1895, Berne; the seventh, August 7–12, 1899, Baden-Baden; the eighth, September 3–8, 1905, Budapest; the ninth, September 13–19, 1909, The Hague; the ninth, will be held in 1914, in London.

Edward Preble.
T. L. Stedman.

**Congress of American Physicians and Surgeons.**—At a meeting of the American Surgical Association held in Washington, April 28, 1886, Dr. Claudius H. Mastin of Mobile submitted a proposition that the national special societies then in existence (nine in number) should hold their meetings simultaneously in Washington. After some discussion the subject was referred to a committee consisting of Drs. J. Ewing Mears, William T. Briggs, and Christopher Johnston. This committee reported favorably on the proposition, expressing its satisfaction with "the perfection of a plan through which the meeting of the special associations named in the memorial, in the city of Washington at the same time of the year may be accomplished, and the meeting of all of these associations in general assembly on such days as may be determined for the purpose of addresses upon the general subjects; such meetings to be held without any formal organization through which the associations meeting will sacrifice their autonomy." At the suggestion of this committee a special committee of five fellows of the association was appointed to confer with committees of the other associations interested in the adoption of a plan of a convention. This larger committee was composed of Drs. Claudius H. Mastin, Charles T. Parks, J. Ford Thompson, Nicholas Senn, and J. Ewing Mears.

The plan of organization submitted by this committee to the several associations was that each society should preserve its own name, constitution, and by-laws, elect its own officers and fellows, hold its own sessions apart from the others at the time and place of meeting, publish its own transactions, and do all other acts of which, by virtue of its constitution and by-laws, it had the inherent right to do, thus

preserving its own autonomy. The Congress would be composed of these special societies when in convention, and its meetings would be held annually in the city of Washington. The constitution and by-laws of the Congress to be formed by a committee composed of a like number chosen from each separate society. The opening session of each annual meeting of the Congress to be devoted to such general business as might pertain to the interests of the association as a whole. The Congress to be presided over by a president, elected annually, who should deliver the opening address upon the first day of the session.

The suggestion was received favorably by the other societies and an executive committee, with Dr. William Pepper, chairman, was appointed to arrange the details. At a meeting of this committee in Philadelphia on October 5, 1887, it was decided that the Congress should meet triennially, instead of annually as at first proposed, and September, 1888, was fixed as the date of the first Congress. The officers chosen were: *President*, Dr. John S. Billings; *Vice-Presidents*, the Presidents of the constituent societies; *Treasurer*, Dr. William H. Carmalt.

The societies organizing the Congress were: American Surgical Association, American Otological Society, American Ophthalmological Society, American Laryngological Association, American Neurological Association, American Dermatological Association, American Climatological Association, American Association of Genito-urinary Surgeons, and Association of American Physicians.

At the birth of the Congress two more societies applied for admission, namely, American Orthopedic Association, and American Physiological Society; and at the same time two new societies were organized, American Pediatric Society and Association of American Anatomists, which were subsequently admitted to the Congress. The American Gynecological Society, already in existence, at first held aloof, but joined the Congress later.

The first two Congresses met in September, but from the third Congress on the meetings have been held in May. The Congresses have been held every three years, with the exception of the seventh Congress which met four years after the sixth. The Presidents of the successive Congresses were: John S. Billings (1888), S. Weir Mitchell (1891), Alfred L. Loomis (1894), William H. Welch (1897), Henry Bowditch (1900), William W. Keen (1903), Reginald H. Fitz (1907), Edward L. Trudeau (1910), William C. Gorgas (1913).

At the ninth Congress, held in May, 1913, there were fourteen constituent societies.

T. L. Stedman.

**Congress, Pan-American Medical.**—At the opening session of the forty-second annual meeting of the American Medical Association, held in Washington, May 5–8, 1891, Dr. Charles A. L. Reed of Cincinnati introduced a motion that an invitation be extended to the medical profession throughout the Western Hemisphere to take part in a Pan-American Medical Congress to be held in the United States, and that a committee be appointed to formulate plans and decide upon the place and date of meeting. The motion was adopted and a committee was appointed consisting of Dr. C. A. L. Reed of Cincinnati, Chairman, Dr. J. W. Carhart of Lampasas, Texas, Secretary, and Dr. I. N. Love of St. Louis, Treasurer. This committee held several meetings and in January, 1893, reported that an organization had been effected in every State and territory in the United States and in every country and colony in the two Americas, including the West Indies and Hawaii.

The *First Congress* met in Washington, September 5–8, 1893, under the presidency of Dr. William Pepper of Philadelphia. It was largely attended, its sessions were marked by great enthusiasm, and it was decided to meet again in three years.

The *Second Congress* was held in Mexico City, November 16–19, 1896. Dr. Manuel Carmona y Valle was president. Public Health was the keynote of the sessions and the necessity was urged of the establishment of a Department of Public Health as an essential part of every American government.

The *Third Congress* was held in Havana, February 4–7, 1901, under the presidency of Dr. Juan Santos Fernandez. It was at this Congress that the announcement was made that the U. S. Army Commission under Major Walter Reed had confirmed by a series of convincing experiments the theory of mosquito transmission of the virus, long held and vigorously supported by Dr. Carlos J. Finlay of Havana.

The *Fourth Congress* was held January 3–7, 1905, at Panama, under the presidency of Dr. Julio Icaza. The scientific work of the Congress was somewhat hampered and the festivities dampened by the non-arrival of fifty delegates from the United States who had chartered a steamer to bring them from New Orleans. The ship was due the day before the opening of the Congress and her delay was the cause of considerable anxiety. She arrived on the last day of the session. The belated delegates, on learning that they could not reach Panama in time, had held several meetings and read and discussed the papers intended for the Congress. These papers and discussions were made part of the transactions of the Congress.

The *Fifth Congress* was held at Guatemala City, August 5–10, 1908, under the presidency of Dr. Juan J. Ortega.

The *Sixth Congress* convened in Lima, Peru, August 3–10, 1913. There were eight sections, dealing respectively with anatomy, bacteriology, medicine, surgery, hygiene, physics, veterinary medicine, and odontology. The meeting was held at the same time with those of the Latin American Medical Congress and the Congress of Hygiene.

T. L. Stedman.

**Coniferæ.**—*The Cone Family* (*Pine Family*, in the broad sense). According to some authors, and probably correctly, it is subdivided into the *Pinaceæ* and *Taxaceæ*, but, for convenience, we here follow Engler and Prantl, in considering both under the title *Coniferæ*. The family contains between thirty and forty living genera, and ten times as many species, besides a number of fossils. They grow mostly in temperate climes, especially the northern. Probably no other family is of greater interest. These trees represent a flora for the most part extinct, and are closely related to those which produced our coal. They are not so well adapted to present conditions as most plants, and their tenure of life may be regarded as on the whole weak, and themselves destined, for the most part, to early extinction. The largest known trees are members of this family. They yield almost all of our soft building lumber. They yield our vegetable tars, pitches, and turpentines, though apparently some of the trees yielding these will be practically extinct within a few years. Through extinct relatives, their relations to coal tar explain the close similarity between the two classes of products. The seeds of a number constitute important foods. Medicinally the family is of great importance, being very rich in volatile oils, of which those of juniper, cedar, turpentine, savin, cypress, and others, are important drugs. Empyreumatic oils similarly used are represented by those of tar and cade. Amaroids, glucosides, and at least one alkaloid, with an abundance of tannin, also occur. Because of the close similarity in nature and properties between these products, only the most important are treated in

this work. The number of pines, spruces, firs, larches, cedars, and related plants in use is very great.

HENRY H. RUSBY.

**Conium.**—CONIUM FRUIT (incorrectly *"Seed"*), HEMLOCK, *Poison Hemlock.*

The full-grown, but unripe fruit of *Conium maculatum* L. (fam. *Umbelliferæ*) carefully dried and preserved, and yielding, when assayed by the U. S. P. process, not less than 0.5 per cent. of coniine, (U. S. P.). The leaves, formerly offical, are no longer so. This plant is a stout, erect, biennial herb a meter or more (three to six feet) in height, with a long, simple or forked, rather fleshy, yellowish-white root two centimeters or so in diameter, and a smooth, branching, striated or furrowed, purple-spotted, dark-green, hollow, slightly glaucous stem. The spots are small and rather numerous; the pith cavity is closed at the joints of the stem. The characters of the leaves and white flowers are well displayed in the accompanying cut.

Hemlock is a common Old-World plant, occurring in the temperate portions of Europe, and even Africa. It is also rather common in many places, as an introduced weed, in the United States. It affects rich and moist waste places, especially swamps and brooksides and damp and shady gardens. It is easily distinguished from most harmless *Umbelliferæ* by its spotted stem, short, thick, disagreeable-smelling fruits, and the absence of oil-bearing vittæ in the latter. Cicuta (see *Poisonous Plants*) is very easily mistaken for it, but both are similarly poisonous.

Conium is notorious as an ingredient of the state poison of the ancient Greeks, by which the philosopher Socrates met his death. It is mentioned by several Greek writers of about the same time, and by numerous Latin ones since—by these often under the name *Cicuta.* It was used as a medicine by English and Scotch physicians several hundred years ago, but its employment under modern ideas of medicine dates from the time of Stoercke, about seventy-five years since. The use of the term *Cicuta* as the name of the hemlock by Latin authors has created some confusion, which was not diminished by Linnæus when he gave the latter name to the related genus.

All parts of hemlock are active, and have been employed in medicine. The drug should be carefully and quickly dried, without heat. As the active principles are volatile, conium deteriorates rapidly, and should be considered inferior if more than one season old. The intensity of odor developed by moistening it, and especially by treating with potash, is a rough way of estimating its value. The leaves are especially unstable; their odor, when fresh and green, is strong and disagreeable, and developed still more so by the potash; when dry they often have no strength or value. The fruits are alone official in the United States, the dried leaves having proved to be generally worthless in this country. They are thus described in the Pharmacopœia: "About one-eighth of an inch (3 mm.) long; broadly ovate; laterally compressed; grayish-green; often divided into the two mericarps, each with five crenate ribs, without oil tubes, and containing a seed which is grooved on the face; odor and taste slight." They hold their strength comparatively well, and yield, on the whole, more uniform preparations than even the fresh leaves.

COMPOSITION.—Conium contains but very little *essential oil* compared with the aromatic members of the family, and that little is neither pleasant nor useful. Its most important constituents are two or three closely related alkaloids.

The most important of these in quantity and activity is coniine, also called conicine and cicutine, which in the plant exists combined with one of the common vegetable acids, probably malic, to the extent of about one-half per cent. in the fruit. The leaves contain much less. It is a strongly basic, colorless, oily liquid, of penetrating odor, closely resembling that of urine or the nests of mice, and a sharp, burning, tobacco-like taste. It is volatile at ordinary temperatures, and boils at 166° to 166.5° C. *In vacuo* it can be redistilled without change, but in the air a portion is decomposed. It becomes thicker and yellow upon prolonged exposure,

FIG. 1526.—Conium maculatum L.

and finally, resinous looking. Specific gravity, 0.88. Chemical composition, $C_5H_9,NH,CH_2,CH_2,CH_3$. It is freely soluble in alcohol, chloroform, the essential oils, etc., but only to the extent of one per cent. in water. It unites with acids, forming neutral salts, which are often crystallizable. That most used is the hydrobromate, in white needles, soluble in two parts of water or of alcohol. Complete purification of coniine is difficult to accomplish.

The second alkaloid, *conhydrine* or oxyconiine, is solid and concretes in the head and tube of the retort in pearly, iridescent, white, foliaceous crystals. It has a faint, conium-like odor, melts at 118° to 121° C., and boils at 220° to 225° C. It is soluble in alcohol and slightly so in water. Conhydrine can be converted into coniine by abstracting the elements of water with phosphoric anhydride. The proportion of conhydrine in conium is much less than that of coniine. Methyl coniine is usually present in commercial coniine and is probably a constituent of the drug itself. The coniine of the market is also apt to contain some pseudo-conhydrine dissolved in it, which can be separated by freezing. This is white, crystalline, soluble in alcohol and water.

The physical properties of coniine and conhydrine are very nearly those of an essential oil and its camphor.

Action and Use.—The action of conium may be regarded as entirely that of coniine; conhydrine and methyl conine, besides their smaller proportion, are physiologically only coniine reduced; the oil and other constituents (vegetable acids, etc.) amount to nothing.

It is very difficult to interpret and harmonize the phenomena attending the action of coniine. Pharmacologists are not agreed as to the mode of their production, and they will be considered here only in their practical bearing. The drug is promptly absorbed from the stomach, very slightly if at all locally, circulates as coniine, and is rapidly excreted through the kidney. It is a nauseating depressant, the effect varying in degree from slight languor and weakness, through nausea, salivation, weak perspiration, vomiting, great muscular weakness, results in general similar to sea-sickness, up to complete collapse and death by respiratory failure, after preliminary stimulation. There is dilatation of the pupil, perhaps after temporary contraction, especially upon local application. There are evidences of vasomotor depression. There is slight depression of the cardiac ganglia. There may be temporary and slight tremors and muscular twitchings, though the later, and strictly speaking physiological effect is opposed to these, destroying them when they already exist. There is little disturbance of sensation proper, and intelligence is little or not at all affected. The one important element is depression, or paralysis of the motor nerve endings. There is apparently, at first, central stimulation, followed by depression, beginning below and passing upward. The peripheral paralysis referred to also apparently proceeds gradually along the nerve trunks. The best authorities agree that conium has failed in nearly all the therapeutic uses to which it has been put. Most of these uses have centered about the theory that it relieves pain, in spite of its failure to affect sensory nerves. The fact is that when pain is kept up through muscular twitchings, commonly themselves induced by existing pain, conium prevents this aggravation by cutting these movements short. In any case, this appears the only use for which it can be recommended.

In administering conium, it is most important that the nature of its constituents be remembered. Coniine, the most important, is volatile, so that careless manufacture is destructive to activity. Long exposure to the air also induces destructive changes. The greatest care should thus be taken in selecting preparations, and only those which are assayed should be accepted. The official fluid extract must contain 0.45 per cent. of coniine. Its dose is one to five minims. The extract, no longer official, should contain 2.5 per cent. of coniine, and may be given in doses of one-fourth to one grain (0.015–0.06).

Poisoning.—The symptoms of poisoning have been given in considering the action of the drug. About two grains of coniine is regarded as a fatal dose. Free vomiting with an abundant supply of warm water, should be induced. Digitalis and alcohol, or small doses of nitrites, should be given to aid the circulation, and strychnine or picrotoxin for the respiration. Mechanical stimulation, heat to the extremities and oxygen in forced respiration should be resorted to in extreme cases.

Henry H. Rusby.

**Conjugation.**—The process in which two protozoans come together and exchange materials. It is roughly comparable to the fertilization phenomena of higher animals. Two protozoans do not have to be of diverse ancestry in order to conjugate, but they must be sexually mature, and the occurrence of conjugants in a culture may also be influenced by other factors, such as the amount of food present, the chemical constitution of the medium, etc. See *Protozoa*.

A. S. P

**Conjunctiva, Diseases of the.**—Anatomy of the Conjunctiva.—The conjunctiva is a mucous membrane whose epithelial surface is continuous at the lid margins with that of the skin, and at the corneal limbus with that of the cornea. The conjunctiva is firmly attached to the tarsal surface of the lids, but in the transitional folds and on the eyeball is very loosely adherent to the underlying tissues. In the latter regions it therefore easily undergoes extreme swelling. Normally, the conjunctival surface is moistened and cleansed by the flow of tears, proceeding from the orifices of the lacrymal glands at the temporal end of the upper cul-de-sac, toward the puncta lacrimalia near the inner canthus. The mucus secreted from the conjunctiva comes from goblet cells, whose number and activity is greatly increased in various inflammatory processes. The subepithelial tissue of the tarsal and transitional regions contains a layer of adenoid tissue, and in most grown persons a few small lymph follicles. In the region of the tarsal conjunctiva are true papillæ, which produce irregularities of the surface only when hypertrophied by disease, such as trachoma or vernal conjunctivitis.

Hyperemia.—Quite apart from any distinct inflammatory process, or invasion by bacteria, the conjunctiva of the lids may present a more or less chronic hyperemia. The vessels are engorged, and the surface appears redder and rougher than the normal, without any marked thickening of the tissues. The patient may complain of a burning sensation, or of scratching with movements of the lids, and there may be increased lacrymation or some collection of mucus after the night's sleep. The condition arises most frequently from uncorrected error of refraction, especially when associated with excessive use of the eyes for close work. Other causes are much exposure to dust or strong light, the vicissitudes of the weather, or general constitutional disturbances such as alcoholism, febrile diseases, gout, and indigestion. It is also particularly liable to occur as the result of inflammation or chronic congestion in anatomically related structures, such as the lacrymal passages and the nose and its accessory sinuses.

The *treatment* consists mainly of the removal of the cause, if this is possible. Glasses should be prescribed, where necessary. The nose and lacrymal system should be attended to. Relief may be obtained from the use of a mild eye-water, such as a solution of boric acid; or it may be desirable to employ one of the astringents, tannin or zinc. Bathing the eyes with water as hot as can be borne, for a few seconds at a time, is often beneficial.

Conjunctivitis.—Inflammation of the conjunctiva may arise from a great variety of causes, mechanical, chemical, or bacterial. The cause may be carried in the blood of the patient, or consist of an invasion from the external world. The latter division includes the bacterial infections, the effects of lime, acids, dust, and sand, and the specific irritations produced by the pollen of certain plants, especially in connection with hay fever. For such forms of conjunctivitis as trachoma, vernal catarrh, and pemphigus, the specific influence of microorganisms has not yet been clearly demonstrated, but appears probable. Microscopic study of the discharge is desirable in every case of conjunctivitis. In a few cases it establishes a doubtful diagnosis, and at the same time furnishes a distinct indication for treatment. Bacteria are probably always present in the normal conjunctival

sac. The most frequent are the xerosis bacillus and the *Staphylococcus albus*, both of which are pathogenic only in exceptional conditions, as after chemical or mechanical injury. Less commonly the normal sac yields the *Staphylococcus aureus*, pneumococcus, *Streptococcus pyogenes*, the diplobacillus of Morax-Axenfeld, the influenza bacillus, or the *Bacillus subtilis*.

*Exanthematous Conjunctivitis.*—Conjunctival involvement in the acute exanthemata may be very slight, amounting only to a simple hyperemia, or may be so severe as to be accompanied by extreme swelling and suppuration. Marked redness of the eye is a characteristic symptom of a pronounced case of scarlet fever. Measles may cause a severe reaction. In smallpox, the conjunctiva is sometimes the seat of pustules. The condition usually subsides with the disease of which it is an accompaniment, and local treatment is generally limited to the use of a boric-acid wash.

*Acute Catarrhal Conjunctivitis.*—This name should be applied only to those cases of conjunctivitis in which severe suppuration and marked structural changes in the conjunctiva do not occur, and which present merely redness, swelling, and moderate discharge. The patient feels as though he had sand in his eyes, and there is a sense of heat. The lids swell somewhat, and there are more or less photophobia and lacrymation. The causes do not differ essentially from those mentioned under Hyperemia of the Conjunctiva. A part is also played by some of the pathogenic bacteria, especially the pneumococcus, staphylococcus, and streptococcus. In moderate cases, the pathological changes are largely limited to the palpebral conjunctiva, leaving the eyeball but little affected. The swelling of the conjunctiva of the lids, especially the upper, frequently convinces the patient that he has a foreign body in the eye. The discharge may be slight, and only noticeable in the morning, being washed away by the tears during the day; or may be fairly profuse. There may be slight disturbance in vision from the presence of mucus on the cornea. The pain is usually spoken of as a smarting, itching, scratching, or burning. The discharge of this, as of other forms of conjunctivitis, consists of varying proportions of mucus, lacrymal fluid, leucocytes or pus cells, desquamated epithelial cells, and bacteria.

In practically all cases the prognosis is excellent, recovery commonly occurring in the course of a few days. The treatment consists in removal of any known cause, caution in use of the eyes while the condition persists, the use of a boric-acid wash, or of mild astringent collyria, weak solutions of zinc sulphate or alum being particularly beneficial. The use of occlusive dressings is undesirable, although tinted spectacles relieve the photophobia.

*Diagnosis Between Acute Conjunctivitis and Other Inflammations.*—Very serious damage is often done by the neglect resulting from a mistaken diagnosis of conjunctivitis. It is therefore necessary to point out the principal characteristics which distinguish this condition from iritis on the one hand and inflammatory glaucoma on the other. In either, the conjunctiva may be greatly congested and the lids swollen. But in iritis the iris is likely to be discolored, the pupil if not fixed by adhesions is small and sluggish in its reaction to light, and the corneal limbus is surrounded by a zone of deep hyperemia or "ciliary injection." The latter is diffuse, rather purplish in color as compared with the brick red of the conjunctival vessels, and cannot, as is the case with the conjunctival engorgement, be readily blanched by pressure with the finger. In conjunctivitis the redness due to vascular congestion tends to be most marked toward the culde-sac, the eye being whiter as the cornea is approached; whereas in iritis the opposite arrangement usually prevails. Photophobia is more pronounced and invariable in iritis. In glaucoma the large episcleral vessels are characteristically distended, the rest of the conjunctiva being often relatively free from redness. But on careful examination a mistake should usually be impossible, since in inflammatory glaucoma the pupil will be dilated and irresponsive to light, and the tension of the eyeball will be increased, as contrasted with the normal tension of conjunctivitis.

*Acute Contagious Conjunctivitis.*—This is the disease which is known to the laity as "pink eye," although many cases of acute conjunctivitis receive this title which are not epidemic in character. It is a severe contagious infection, by some writers regarded as a specific disease, in which case it is often given the name of "Koch-Weeks" conjunctivitis. The majority of cases of acute contagious conjunctivitis are due to a small bacillus which was first completely studied by Weeks, but was also described independently by Koch, who discovered it in the acute epidemic conjunctivitis of Egypt. The organism resembles that of mouse septicemia, and measures one to two micra in length. Some authors have regarded this bacillus as identical with the influenza bacillus, and have therefore considered acute contagious conjunctivitis to be a manifestation of influenza. Other epidemics of acute conjunctivitis have been attributed to the pneumococcus, the *Micrococcus lanceolatus*, and the *Diplococcus pneumoniæ*.

During the incubation period of thirty-six to forty-eight hours, the only symptom is a slight itching of the eye. From this time to the fourth day the mucopurulent secretion steadily increases until it becomes quite abundant and yellow. The general discomfort is marked, the lids are swollen, the flow of tears is increased, and there may be coryza and frontal headache. The acute stage usually lasts from three to seven days. The popular expression "pink eye" is derived from a strikingly red appearance of the eyeball due to congestion of the ocular conjunctiva. During the early part of the acute stage there are often numerous small hemorrhages beneath the bulbar conjunctiva. A bright yellow mass of secretion at the inner canthus in the mornings is regarded by Weeks as almost pathognomonic of the disease. The congestion of the palpebral conjunctiva is slower to subside than that of the eyeball, and a sense of dryness of the conjunctiva persists often for several weeks. If neglected, follicular hypertrophy may last a long time. Complete recovery usually occurs in two or three weeks. Although relapses and recurrences are common, yet the disease is essentially self-limited. Corneal ulcer occurs as a very rare complication, and in from four to six per cent. of the cases (according to Weeks) a pseudomembrane develops. The disease is contagious in the extreme, being probably carried by towels, bathing water, and the like, as well as by direct contact.

The growth of the Koch-Weeks bacillus is decidedly inhibited by reducing the temperature of the conjunctival sac to 32° C. This may be accomplished by applying to the lids every one and a half minutes pieces of gauze which have been laid on a block of ice. The process may well be repeated for two or three hours at a time several times during each twenty-four hours of the acute stage. Frequent cleansing with sterile boric acid solution is also advisable. Argyrol or protargol solution may be instilled several times daily, or if the attack is severe a rather strong solution of silver nitrate (one or two per cent.) is applied to the everted lids. A weaker solution of the same drug is profitably used in the same way during the convalescent stage until the secretion stops. Bandages, and the popular domestic poultices, are reprehensible in that they favor the growth of the germ, in this or any other form of conjunctivitis.

*Diplobacillus Conjunctivitis.*—The diplobacillus of Morax and Axenfeld gives rise to a frequently unrecognized form of sub-acute or chronic conjunc-

tivitis. The disease begins insidiously, often affecting one eye some time before the other. Occasionally, the specific organism is responsible for a rather acute conjunctivitis, with fairly marked swelling of the lids and a good deal of discharge. In the great majority of cases, however, the symptoms of the disease are mild, and for this reason the patient often neglects for a considerable period to seek relief. The conjunctiva is reddened and somewhat swollen, and there is a tendency to congestion and thickening of the lid margins. The fact that the redness of the lids is commonly most marked at the commissures has led to the name "angular conjunctivitis" being applied to the disease. The discharge is usually slight, rather whitish, and stringy, and tends to adhere to the lid margins, or to collect in the lower cul-de-sac or at the inner canthus. The symptom most frequently complained of is a burning, especially on use of the eyes. The disease may last from weeks to months or even years. Superficial infiltration or ulceration of the cornea sometimes occurs. Petit's bacillus, similar to that of Morax and Axenfeld, has been shown to produce a similar disturbance.

The clinical picture usually renders the diagnosis simple, but there are a number of cases in which the condition is liable to be overlooked unless microscopic examination is made. Although the organisms may not be very numerous in a smear from the discharge, yet their appearance is characteristic. The bacillus is a large one, and occurs in pairs, each individual having squarish ends and measuring one to two micra in length and half as much in breadth. The diagnosis once made, treatment always consists in the use of a zinc salt, commonly the sulphate. This drug appears to have a specific action, but must be persisted in for a week or so beyond apparent recovery, as the disease is particularly prone to recurrence, and the organisms may persist for some time without clinical signs. If used in the surgeon's office, a strong solution of the sulphate of zinc, even of five or ten per cent. strength, should be applied on a cotton swab to the everted lids, and the application repeated every two or three days. If the patient is given a prescription, this should be for from one to five grains to the ounce of distilled water, to be instilled two or three times daily. The smarting produced by the zinc salts is rendered more tolerable by the addition of boric acid to the solution.

*Pneumococcus Conjunctivitis.*—As has been noted above, the pneumococcus frequently inhabits the conjunctival sac without producing a diseased condition. But the organism may give rise to varying degrees of purulent inflammation, at times resembling the disturbance produced by the Koch-Weeks bacillus, or again so severe and accompanied by so much swelling and discharge as to simulate a gonorrheal ophthalmia. The disease is more or less contagious, and sometimes appears in epidemics. The prognosis of pneumococcus conjunctivitis is excellent. Salicylate of zinc has been stated to be specific for this condition.

*Streptococcus Conjunctivitis.*—This is rare. The streptococcus is the cause of a few cases of pseudomembranous conjunctivitis.

*Influenza Bacillus Conjunctivitis.*—Zur Nedden reported thirteen cases of conjunctivitis from this cause. In ten of them the influenza bacillus was the only organism found, and in the other three it was associated with the pneumococcus. The condition occurs most frequently in the young, especially in connection with inflammations of the nose and throat, tear sac, and middle ear. As regards the eye the prognosis is good.

*Gonorrheal Ophthalmia, Purulent Conjunctivitis.*—Inflammations having the same essential character, yet varying more or less distinctly in their clinical manifestations and results, follow infection by the gonococcus in three several groups of cases. To these three forms of the same disease are given the names ophthalmia neonatorum, or gonorrheal infection of the eyes of the new-born; gonorrheal conjunctivitis, or a like infection in adults; and purulent or gonorrheal conjunctivitis of young girls; the last expression however embodying a distinction less frequently made. Infections clinically resembling those from the gonococcus, and equally contagious, have been shown to occur in a certain percentage of cases in which the gonococcus cannot be demonstrated, or other pus-producing organisms are the definite cause of the disease.

*Ophthalmia Neonatorum.*—In sixty to seventy per cent. of all cases purulent ophthalmia of the new-born is due to infection with the gonococcus of Neisser. In rare instances, the child is born with the disease already developed, the infection having probably been received after rupture of the membranes in a slow labor. In the majority of cases infection occurs from some portion of the genital tract of the mother, either during labor or shortly after birth. In some cases, especially those in which the disease develops at an appreciable interval after birth, the infection is conveyed by the hands of the mother or nurse, or on various objects which come in contact with both the mother's genitals and the baby's eyes. The inflammation may be produced, in addition to the gonococcus, by the pneumococcus, streptococcus, diplobacillus, colon bacillus, and the various forms of staphylococcus. The pneumococcus ranks next to the gonococcus as regards frequency.

The gonococcus rapidly invades the conjunctiva, developing in its superficial layers, and causing a violent reaction, with resulting infiltration and edema, and pouring out of pus cells. The conjunctival papillæ become much enlarged, producing after a few days the appearance of granulations on the inside of the lids. The disease excels other forms of conjunctivitis in the rapidity and severity of its development. Lacrymation and injection are rapidly followed by great swelling, and the appearance of an abundant mucopurulent discharge, which at first may be rather thin and straw-colored from free admixture of tears. The secretion later becomes thicker, yellow or greenish yellow in color, and is produced very rapidly.

The swelling of the lids is often so extreme that, quite apart from the struggles of the child, it is difficult for the surgeon to separate the lids. On the eyeball also the conjunctiva becomes chemotic, often overhanging the cornea in folds. Mild cases occur in which all the symptoms are less pronounced. Whether the diagnosis is considered certain or doubtful, however, a microscopic examination of the secretion should be made. If the diplococcus is found, characteristically grouped within the leucocytes as well as free outside them, the diagnosis can usually be regarded as established. Rarely the meningococcus, which has the same microscopic appearance and arrangement, gives rise to a like clinical picture. If any uncertainty is felt, culture tests should be applied. The result of the bacteriological study should be carefully recorded, and impressed upon the parents, in view of the possibility of later medicolegal complications.

The serious prognosis always attached to this disease depends on the danger of corneal complications. The earlier the case is seen and actively treated, the better the chances of avoiding corneal injury, although there are cases which seem doomed from the start, and in which the cornea is destroyed with great rapidity. Corneal ulcers frequently develop in close proximity to the groove formed by the overhanging chemotic conjunctiva. At other times a central ulcer forms. If within the first day or two of the disease the cornea appears hazy and lusterless, the prospect of ulcer formation is almost certain. If an ulcer has once formed, it is very likely to go on to perforation, with the results discussed in the article on *Cornea, Diseases of the.*

After an acute stage lasting usually from five to eight days, the swelling of the lids diminishes, and the discharge becomes thinner and less abundant. Complete recovery commonly occurs after several weeks, but papillary hypertrophy of the lid conjunctiva often persists for a further period. Rarely, scar tissue is formed in the conjunctiva. If the cornea has been seriously disturbed the eye seldom recovers useful vision. Panophthalmitis or secondary glaucoma may render enucleation necessary.

Measures to avoid the development of ophthalmia neonatorum should be taken in every case of childbirth where the mother is known to have a gonorrheal infection, or where uncertainty exists as to the presence of such a condition. The best procedure is that known as Credé's method. As soon as the child's head is born, the eyes are cleansed, and a solution of silver nitrate dropped into the conjunctival sac. The strength of solution originally recommended was two per cent., but a one per cent. solution is probably efficient, and is less likely to produce a severe reaction. Furthermore, nurses, as well as persons having the disease, should be thoroughly acquainted with its infectious character, and also its fatal effect on the eye.

*Treatment.*—In the treatment of a case of gonorrheal conjunctivitis, the most important detail is the mechanical cleansing of the eye from discharge. This should be done as frequently as is necessary to prevent collection of pus in an appreciable quantity. The lids are separated, any ropy material wiped away with cotton pledgets, and the eye and conjunctival sacs gently but thoroughly irrigated with an aseptic or feebly antiseptic solution. Boric acid or physiological salt solution is probably as efficient as any other preparation, although a weak solution of permanganate of potassium has many adherents. Proper attention to the matter of cleansing calls for night as well as day nursing. It is extremely important, in separating the lids, to avoid the risk of even the slightest abrasion of the corneal epithelium. In the early stages, especially where the swelling of the tissues is very marked, the use of iced applications is often recommended; but they must not be employed with such excess of enthusiasm as to endanger the vitality of the parts, and they must be abandoned at once on the appearance of any disturbance of the cornea. The best way in which to apply cold to the eye is by means of little pads of gauze which have been laid on a block of ice. These are changed every minute or so, and subject to the condition of the cornea, the treatment may be kept up almost continuously. If a corneal haze or ulceration develops, hot rather than cold applications must be used, and a solution of atropine (one-half to one per cent.) is to be dropped into the eye several times daily.

A great deal of discussion has occurred as to whether silver nitrate, or one or other of the newer organic compounds of silver, is to be relied upon for the actual antiseptic treatment of the disease. The general trend of opinion seems to be that in severe cases reliance should be placed only on the nitrate, which is used, according to the severity of the inflammation or the predilection of the surgeon, in strength varying between one and four per cent. A cotton swab, saturated with the solution, should be brushed over the whole conjunctiva of the lids and culs-de-sac, as far as possible. The application should usually be made once in twenty-four hours, but in milder cases may not be required oftener than every forty-eight hours, while in severe cases its employment more frequently than once daily is sometimes advisable. A new application should not be made until the reaction caused by the preceding one, as judged by a red and raw appearance of the conjunctiva, has given place to the edematous surface characteristic of the disease. In the later stages of the attack a one-half per cent. solution of silver nitrate is ordinarily sufficient, or a stronger solution may be used at longer intervals. In the milder cases, a solution of argyrol in ten to twenty-five per cent. strength, or a somewhat weaker preparation of protargol, may be used at short intervals. Stephenson has had very satisfactory results from the use of argyrol, a twenty-five per cent. solution being brushed over the everted lids after wiping the surface free from adherent discharge. These organic salts may also be employed for instillation every hour or so between the applications of silver nitrate.

In cases where the swelling of the lids offers a serious obstacle to drainage and to treatment, canthotomy, or division of the tissues at the external canthus, is advisable. Or in young infants the upper lid may be split by a vertical incision.

*Gonorrheal Conjunctivitis of Adults.*—This differs in no essential from the infantile form. In the average, however, it is even more malignant than the latter. Weeks states that the cornea is involved in seventy per cent. of all adult cases. Since the patient is often of a weakly constitution, rest and supportive treatment may be called for, especially the use of iron and strychnine. To enable the patient to get about, while protecting the other eye from infection by the one first involved, the sound eye may be covered by Buller's shield. This consists of a watch glass which is fastened to the face and sealed toward the diseased eye with strips of adhesive plaster.

*Gonorrheal Conjunctivitis of Young Girls.*—Occasionally, epidemics of gonorrheal vaginitis have been reported as occurring in asylums and other institutions. The cases of conjunctivitis incident to these outbreaks are usually much less malignant than those in the adult.

*Metastatic Gonorrheal Conjunctivitis.*—This relatively rare affection is almost always bilateral, and produces a swelling chiefly involving the bulbar conjunctiva, with local heat and redness but no purulent discharge. Whether it is due to the gonococcus directly or to its toxin is an unsettled question. It may be the unique symptom of systemic gonorrhea, or may accompany or follow arthritis or other general manifestations. It may be followed by iritis.

*Pseudomembranous Conjunctivitis.*—A distinction is still made in many works on ophthalmology between pseudomembranous, or croupous, and diphtheritic conjunctivitis. But the distinction has no real scientific basis. A pseudomembrane consists of a layer of fibrin, which may be more or less firmly adherent to the underlying mucous membrane. Such a layer may occur in a mild degree in cases of gonorrheal conjunctivitis, or even in severe catarrhal conjunctivitis. In some true cases of infection by the Klebs-Loeffler bacillus, the inflammation is not severe nor the membrane formation accompanied by deep necrosis of the tissues. On the other hand, some of the most destructive cases of pseudomembranous conjunctivitis are due to the streptococcus. In the mild and superficial cases there is very little danger of injury to the cornea, whereas in the severe cases the prognosis as regards the cornea, and therefore as regards vision, is extremely bad. This deep-seated variety is characterized by an infiltration of the lids of board-like hardness, which resists attempts at eversion. The disease is likely to be an accompaniment (where it occurs at all) of diphtheria of the nose and throat. The secretion is much scantier than in gonorrheal infections. The whitish or grayish-yellow membrane is separated with great difficulty from the tissues and leaves a bleeding surface. It may cover the entire conjunctival surface or there may be uncovered areas. Rarely, the necrosis may be so severe as to lead through subsequent cicatrization to marked deformity of the lids. It must not be forgotten that burns and chemical injuries may produce a similar local picture; but in bad cases of diphtheritic conjunctivitis, even if local manifestations are limited to the eye, there is likely to be a general febrile reaction.

EXPLANATION OF
PLATE XXIX

## EXPLANATION OF PLATE XXIX.

Fig. 1.—Diphtheritic Conjunctivitis. Everted lid showing a thick pseudomembrane on the mucous membrane; diphtheritic patches are to be seen even on the cutaneous surface of the lid. (Axenfeld.)

Fig. 2.—Trachoma (granular conjunctivitis) in the Stage of Granulation. The entire conjunctiva shows "trachoma follicles" of various sizes. (Axenfeld.)

Fig. 3.—Trachomatous Pannus. The upper portion of the cornea is covered with a network of superficial vessels. (Axenfeld.)

Fig. 4.—Phlyctenular Conjunctivitis; showing typical phlyctenulæ, one of which is seen encroaching on the cornea. (Axenfeld.)

Fig. 5.—Lipodermoid of the Conjunctiva; see also Fig. 9. (Wagenmann in v. Graefe's Archiv., 1910.)

Fig. 6.—Gonorrheal Conjunctivitis. The lids are swollen and glued together, while from the inner corner exudes thick pus. (Axenfeld.)

Fig. 7.—Conjunctivitis Nodosa. (De Schweinitz and Shumway, Trans. Am. Ophthal. Society, Vol. X., Part 2.)

Fig. 8.—Gonorrheal Conjunctivitis, with Lids Everted. (Axenfeld.)

Fig. 9.—Lipodermoid of the Conjunctiva; see also Fig. 5. (Wagenmann in v. Graefe's Archiv., 1910.)

Fig. 10.—Trachoma, Cicatricial Stage. White scars are seen in the tarsal conjunctiva of the upper lid. (Axenfeld.)

Fig. 11.—Parinaud's Conjunctivitis, showing the typical nodular masses on the palpebral conjunctiva of the lower lid and also a swollen preauricular gland. (Sinclair and Sherman, in Trans. of the Ophthal. Society of the United Kingdom, Vol. XXVIII.)

(Figures 1, 2, 3, 4, 6, 8, and 10 are from Axenfeld's Lehrbuch der Augenheilkunde, 3d Ed., Jena, 1912.)

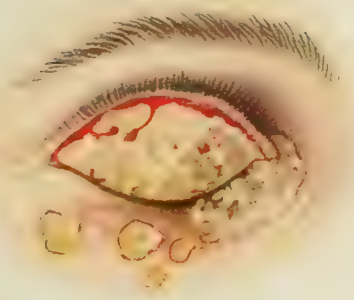

FIG. 1

FIG. 2

FIG. 3

FIG. 4

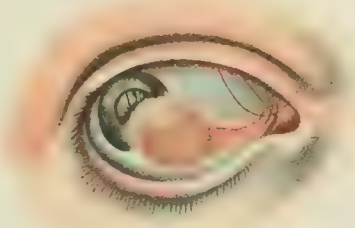

FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 10

FIG. 11

DISEASES OF THE CONJUNCTIVA

Some fatal cases of conjunctival diphtheria have been reported.

As with diphtheria elsewhere, the early recognition of the disease is of the greatest importance. The presence of the Klebs-Loeffler bacillus should be suspected even in moderate cases of pseudomembrane formation not manifestly due to other causes. But the microscopic diagnosis is complicated by the fact that the xerosis bacillus, a common inhabitant of the conjunctiva, cannot be positively distinguished from the diphtheria bacillus except by culture tests. When the diagnosis has been made, local treatment counts for very little, and antitoxin must be used just as in any other form of diphtheria. If this is done early the cornea will probably be saved; otherwise, sloughing of the cornea and loss of the eye are very likely to occur. Where the disease depends on the presence of the streptococcus, injections of antistreptococcic serum will occasionally produce marked benefit. The local treatment will include the use of lukewarm compresses, cleansing with aseptic or mildly antiseptic solutions, and the introduction between the lids of a bland antiseptic salve. The case should be isolated just as strictly as though the disease were in the throat, and in unilateral cases in adults the second eye should be protected in the same manner as recommended for gonorrheal conjunctivitis.

*Abscess of the conjunctiva* is very rare, and usually results from trauma, but sometimes occurs without antecedent injury in badly nourished children.

*Toxic Conjunctivitis.*—This term is applied to conjunctival inflammation or irritation due to a variety of substances, such as the mydriatics, cocaine, aniline dyes, chemical fumes, and insect bites.

Atropine Conjunctivitis.—Prolonged use of atropine (or, less frequently, of other cycloplegics) or a single dose in cases of idiosyncrasy, may result in a marked conjunctival disturbance, usually accompanied by eczematous irritation of the adjacent skin. The formation of follicular granulations on the palpebral conjunctiva and that of the cul-de-sac, may simulate early trachoma. Some cases of irritation from instillation of atropine are probably due to the use of non-sterile solutions. The treatment consists of mild astringent applications and discontinuance of the use of the drug.

*Conjunctivitis Nodosa.*—The hairs of certain species of caterpillar are capable of producing in the conjunctiva, as also in the cornea or even the iris, a peculiar slow inflammation. Tiny nodules are formed, which have been compared to tubercles. The caterpillar hair lies in the center, and is surrounded by zones of leucocytes, giant cells, and epithelioid cells. The nodules are grayish or yellowish, and semi-transparent. They must be excised.

*Chronic Conjunctivitis.*—Neglected refractive errors, nasal disorders, exposure to dust or to glare of light or heat, unhygienic surroundings, or disorders of the nose or lacrymal apparatus, may produce a chronic thickening of the conjunctiva, with slight discharge noticed chiefly in the mornings. Blepharitis marginalis of a chronic character is accompanied by chronic conjunctivitis. The latter disturbance is common in the aged, probably depending on lowered vitality. Some cases are due to the presence of the Morax-Axenfeld diplobacillus. In every case of chronic conjunctivitis where other causes are not clearly at fault, uncorrected or improperly corrected refractive error is to be suspected. Whatever the cause it should be obviated if possible. Relief may be given by occasionally bathing the eyes for a few minutes with very hot water. A solution of one-half or one per cent. silver nitrate, or of tannin, may be applied at intervals to the conjunctiva of the lids, or the patient may be given zinc sulphate in one-fifth to one-half per cent. solution to drop into the eyes several times daily. For very chronic cases, an ointment of yellow oxide of mercury, one per cent., may often be used with advantage every night at bedtime over a period of many months. Where the condition has existed for a long time, it may persist in spite of treatment.

*Concretions in the Conjunctiva.*—This condition, often referred to as lithiasis of the conjunctiva, occurs more frequently in elderly than in young people. It is due to the accretion of inspissated material in the acini of the Meibomian or other conjunctival glands, and appears as slightly elevated, yellowish masses, the size of a small pin-head, beneath the conjunctiva. They are at first of cheesy consistency, but may later become calcareous, and then act as foreign bodies, producing marked irritation. They may be readily removed with the point of a fine needle, cocaine having been first instilled.

*Herpetic Conjunctivitis* occurs in association with trigeminal herpes affecting the lids or cornea.

*Phlyctenular Conjunctivitis.*—A phlyctenule is not, as the Greek original of the word would imply, truly a blister, but a subepithelial nodule. It is a localized inflammatory condition, appearing clinically as a raised point of hyperemia, sometimes yellowish or grayish at the apex, and approached, on the sides toward the conjunctiva, by a number of enlarged blood-vessels. It most commonly lies in close proximity to the cornea, so that on this side no vessels will be found. In most cases the disease affects both conjunctiva and cornea (*q.v.*). The phlyctenule usually breaks down to form an ulcer. The immediate cause is unknown. Weeks is firmly persuaded that this is always the *Staphylococcus pyogenes aureus* which he declares may be demonstrated in cultures carefully made from any phlyctenule. Other writers have just as categorically asserted that the tubercle bacillus is the etiological agent; but all that has been conclusively shown in this connection is that a large proportion of the cases give a positive reaction to the tuberculin tests. The nodule itself is chiefly composed of small round cells.

The disease is common among children who are of the so-called scrofulous diathesis, or in other words who tend to glandular enlargement with catarrhal disturbances of the nose and throat, and to eczema and other diseases of the skin in various parts of the body. A large number of otherwise vigorous patients belong to a class in which *mis*-feeding rather than under-feeding is common; and strict attention to dietetic habits, where this can be ensured, will often of itself produce a cure. Although almost always possessing perfectly characteristic features, the different cases vary greatly in arrangement, severity, and chronicity. The tendency to recurrence is marked. Sometimes the lesions, either single or multiple, appear and vanish in the course of a few days without producing marked symptoms. In other patients, in spite of everything that is done, the eye remains constantly in an inflamed condition over a period of many months. In these cases the sight is almost always permanently impaired from corneal opacity. The disease seldom occurs in adults.

Where the lesions are multiple, the eye may for a time show a general vascularity. The discharge is slight. The usual symptoms are pain, dread of light, and increased lacrymation. Where corneal involvement is marked, the child may refuse to keep his eyes open, and hence become for the time being virtually amblyopic and helpless. Exceptionally, true phlyctenules appear on the conjunctival surface of the lids. The disease is readily distinguished from episcleritis by the fact that in the latter the overlying conjunctiva slides easily upon and independently of the swelling.

The treatment is systemic and local. Thorough attention must be given to details of hygiene and diet, and to surgical conditions in the nose and throat. General tonics may be needed. Probably on account of the part played by gastrointestinal intoxication, calomel seems in many cases to act as a specific. It should be given at first in divided doses to produce

mild catharsis, and afterward at the rate of one-twentieth to one-tenth grain three times daily for several weeks if necessary. The most successful preparation for local use seems to be an ointment containing one per cent. of yellow oxide of mercury. If this is made by a local druggist he must be instructed to triturate very thoroughly so as to avoid the irritation which might result from excessive concentration. The salve may be used once or twice daily, a piece equal in size to a grain of rice being placed inside the lower lid, and then distributed over the eye by massage through the closed lids. If the inflammatory reaction is unusually severe, occasional applications of a solution of tannin in glycerin should be made to the everted lids. Atropine instillations are called for in some cases of marked photophobia, particularly if the cornea is involved.

*Follicular Conjunctivitis.*—For many of the cases to which this name is given, the term Folliculosis of the Conjunctiva might more suitably be employed, since in many instances there are no true inflammatory signs, and the patient may complain of no symptoms whatever. A few of the cases accidentally discovered in school-children who have suffered no inconvenience, but who are declared to have trachoma and are operated upon for that condition, probably belong to this category. It is often hard to decide clinically whether a child is suffering from the first stage of trachoma, or has merely a follicular conjunctivitis. In both conditions there is hypertrophy of the lymph follicles, producing soft rounded or oval elevations in the cul-de-sac. Some authors offer as a diagnostic point the statement that in follicular conjunctivitis the enlarged follicles are found only in the lower cul-de-sac, and in many cases this is true. But it is equally true that in many non-trachomatous cases enlarged follicles may be found in the upper cul-de-sac, especially if the lid is greatly everted, and also beyond either end of the upper tarsal plate. Axenfeld suggests that for cases in which an off-hand, confident diagnosis as between these two conditions would be hazardous, the expression "trachoma suspect" should be adopted. Some authors refuse to draw a sharp line between trachoma and follicular conjunctivitis.

Follicular conjunctivitis is very common among school children, and especially among those whose surroundings are unhygienic. There is also a rather definite relationship between the occurrence of adenoid hypertrophy in the throat and lymphoid enlargement in the lids. For this reason the latter has not unaptly been referred to as ocular or conjunctival adenoids. Many cases are at least aggravated by the need for refractive correction. In other instances the condition follows acute catarrhal or suppurative conjunctivitis, or even the use of atropine. The child may complain of vague ocular symptoms, including burning and smarting of the lids, slight photophobia, and intolerance of close work. Sometimes distinct inflammatory symptoms develop, the lids swelling and a more or less abundant mucopurulent secretion being given off. The treatment is in general that of catarrhal conjunctivitis. Some authors have advised expression of the follicles, and Coover applies his sand-paper operation (see Trachoma) to some cases of follicular conjunctivitis.

*Vernal Conjunctivitis.*—This disease, also known as Spring Catarrh, is relatively rare. In the cases which are true to the title, the disease appears each year in the spring or early summer, to vanish with cold weather and recur in the following year. But in a number of cases the pathological changes and symptoms persist the whole year round, although it may be with diminished intensity in the colder and darker seasons. In the milder forms the changes in the conjunctiva consist of slight thickening and redness, with a velvety appearance of the tarsal surface, due to minute papillary elevations. To subepithelial infiltration and sclerosis are attributed a somewhat characteristic bluish, "skim-milk" appearance of the conjunctival surface. The patient complains of annoying itching of the eyes and lids, burning, photophobia, and distress on using the eyes for close work. There is a scanty stringy discharge of mucoid material.

In the later stages of the more severe cases, the fibrous hypertrophy of the conjunctiva results in the formation of elevations somewhat resembling trachoma follicles, but in their typical forms pedunculated, flattened by pressure, and crowded against one another in a fashion which has led to their being compared with cobble-stones. These appear on the tarsal surface of the upper lid and not in the fornix, in contradistinction to the trachoma follicles, whose favorite site is in the transitional folds. These elevations are commonly mingled with more or less of the stringy secretion already referred to. In some cases there is a tendency to irregular thickening of the conjunctiva at the limbus of the cornea, with increased vascularity of the bulbar conjunctiva, particularly in the area corresponding to the palpebral aperture. Either the lid or the bulbar hypertrophy may be present without the other.

The cause of the disease is unknown. It has been attributed to several bacteria. Many authors have supported Dimmer's contention that it is due to the action of actinic light rays, but the fact that removal from sea level to mountain altitudes is usually beneficial argues against this supposition. Dust may play a part, and the seasonal behavior of the affection, and the fact that it sometimes appears in the subjects of hay fever, suggest the possibility that plant pollens have some influence. The disturbance may be due to the combined influences of heat, light, and dust.

Medicinal treatment is very unsatisfactory, and at the best is usually only palliative. Sharp caustics or powerful astringents should never be used, but the local application of mild astringents often makes the patient more comfortable. The mild salve of yellow oxide of mercury, as mentioned under phlyctenular conjunctivitis, may be beneficial. One part of dilute acetic acid to two hundred and fifty parts of water has been recommended as an application to relieve smarting. A watery solution of ichthyol, and one of sulphate of quinine and dilute adrenalin (1:10,000) have been recommended. But the most effective treatment is usually a summer change of abode, generally to the cooler hill or mountain regions. Protective glasses, especially amber or recently patented tints (Fieuzal or Euphos) which diminish the chemically active rays at the violet end of the spectrum, are often gratefully worn. Refractive errors should of course be cared for, and the condition of the nose should also be investigated. Good results have been reported from the use of the *x*-ray and radium. In cases where the diagnosis is in doubt, Brown Pusey and others have suggested the value of examining the secretion for the presence of eosinophilic leucocytes, which are said to be very numerous in this condition, whereas their frequency in trachoma does not exceed the normal. The prognosis as to ultimate recovery without permanent injury is excellent, even when the disease has existed for years.

Trachoma.—The word trachoma is derived from a Greek word meaning rough. Among other names the disease has been very generally spoken of as granular conjunctivitis or granulated lids; but, as these expressions have been quite loosely applied by the laity and by some physicians, the use of the short and specific term trachoma seems more desirable. The disease is of remote antiquity, having been known (although probably loosely diagnosed) to the physicians of ancient Greece and Rome. It was called very strikingly to the attention of contemporary and later physicians by the effect upon its distribution of Napoleon's Egyptian campaign in 1798–99. From Egypt,

where trachoma has been endemic since the dawn of history, the French troops scattered it through the armies, and so later through the non-combatant populations, of Europe. This process no doubt acquired a more strikingly epidemic appearance from the fact that besides trachoma many patients must also have received infection with the gonococcus or Koch-Weeks bacillus, both of which are also the basis of pandemic ocular disease in the Nile basin.

Trachoma is a contagious disease. The infection is not air-borne, but occurs by contact with secretion from a trachomatous eye, either directly or through utensils, towels, and the like. Yet predisposing circumstances seem necessary for its transmission. The greatest allies of the disease are uncleanliness and ignorance. It is very common among the races of Asia. In Europe, the disease is most prevalent among the poorer Italians, Irish, and Jews; but it is common in most regions where the people are crowded together in insanitary conditions. Yet negroes, in both Africa and the American hemisphere, are remarkably free from it.

Most cases run an extremely protracted course. In many instances its onset is so insidious that the patient is for some time unconscious that there is anything the matter with his eyes. But in another class of cases the commencement of the disease is apparently acute. The symptoms are then largely those of an acute catarrhal conjunctivitis, with swelling of the lids, photophobia, lacrymation, and mucopurulent discharge. Some writers regard these cases as representing a mixed infection, which produces the combined results of trachoma and acute catarrhal conjunctivitis. The patient may complain of severe pain, in which case the cornea will usually show infiltrated areas. At this stage the true nature of the disease may not be recognized, the characteristic lymph follicles being disguised by the edematous swelling of the lids. But, when, either after or without treatment, the sharp initial reaction has subsided, these will gradually reveal themselves.

The granulations vary in size from some which are barely perceptible to others three or four millimeters in diameter. The most typical are commonly compared with sago grains which have been partly soaked in water. They are often to be seen on the tarsal surface of the lids, and indeed may completely cover the inside of the lids, but are largest and most numerous in the transitional conjunctiva, between the eyeball and the tarsal plates. Flattened, watery-looking granulations may frequently be made out on the eyeball itself close to the transitional folds. The typical trachoma follicles are larger than papillary elevations, have a wider distribution, as well as a more edematous appearance, than is usual for the granulations of follicular conjunctivitis, and lack the toughness, the flat cobble-stone arrangement, and the pedicle of the hypertrophied tissue sometimes seen in vernal conjunctivitis. There are, however, as already noted under Follicular Conjunctivitis, a good many cases in which the diagnosis between that condition and trachoma remains for some time in doubt.

When the first sharp attack is over, the case which has begun acutely runs much the same course as those whose early development was more gradual. The patient may suffer but slight discomfort, with moderate mucous secretion, slight increase of lacrymation, and a barely perceptible thickening of the lids. In a fair proportion of all cases of trachoma, the patient only complains during the acute exacerbations which are liable to occur in the early stages, or after later cicatricial changes have resulted in inflammation or loss of vision. By some authors the manifestations of trachoma are categorically divided into several stages, but the progression between these is perfectly gradual. In a few patients, without any treatment, the disease progresses to recovery with but slight permanent damage to either conjunctiva or cornea. But in the majority the tendency is for the hypertrophied lymphoid tissue to undergo cicatrization. In the course of months or years, the masses of lymph cells coalesce, and strands of new connective tissue are formed. These strands increase in number, and contract, and the lymphoid tissue is either extruded or absorbed. The inner surface of the lids, as well as the epithelial surface of the culs-de-sac, comes to consist of a squamous epithelium lying upon an anemic scar tissue. The area of the conjunctiva is greatly diminished, and as a result the lid margin is turned in toward the eye (entropion), and the lashes brush the cornea. The superficial vascular opacity of the cornea which occurs so commonly in trachoma is by some authors attributed to the mechanical irritation of the scarred conjunctiva and of the in-turned lid margin upon the cornea; but pannus frequently occurs in earlier stages of the disease, and there is good reason to suppose that it is in reality a trachomatous infiltration of the cornea. In Egypt, where the incidence of blindness is appallingly great, the late ravages of trachoma are responsible for a large percentage of the cases of defective vision. It is probable that trachoma is due to a microorganism, but it is equally certain that the nature of this microorganism has not yet been proved. Different investigators have described a diplococcus, a fungus, and protozoa which were thought to have an etiological connection with the disease. Mutermilch is disposed to doubt whether trachoma is a disease entity. He regards it as a chronic inflammation of the mucosa, due to a variety of bacteria, and states that the patient is only dangerous to his environment by the capacity for transmitting the acute inflammation which is the starting point of this chronic process.

In the last few years, a great deal of space in the current literature of ophthalmology has been devoted to the so-called trachoma bodies. These were first studied and described by Halberstädter and Prowazek, and by Greeff. They are also referred to as chlamydozoa, inclusion bodies, and trachoma corpuscles. They are found in the superficial epithelial cells in the early stages of the disease. Although described in various stages of development, in their most typical form they appear as minute discoid bodies, lying in the protoplasm of the epithelial cell, flattened at one side where they lie in contact with the cell-nucleus. They are colored blue by the Giemsa stain, and look highly granular. When they have grown so as to occupy a large part of the cytoplasm, the cell ruptures and the granules are extruded. For a time the trachoma body was rather enthusiastically received as the probable cause of trachoma; but since then similar bodies have been demonstrated in non-trachomatous ophthalmia neonatorum, and in the epithelium of the male and female genitalia. Herzog regards the inclusion bodies as metamorphosed gonococci, and believes the gonococcus to be the agent of trachoma. It is pretty clearly established that the trachoma bodies are not the cause of trachoma, and they may be merely the result of incidental degenerative changes in the epithelial cells.

The *prognosis* of trachoma is always uncertain, although bad without treatment. Some cases run a relatively mild though lengthy course, and never produce any great diminution in visual acuity. Other cases, at first seemingly not more severe than the former, relapse again and again, in spite of temporary improvement, and seriously handicap the individual throughout life. If treatment is actively applied before corneal complications have appeared, these may generally be avoided. If corneal disturbances have once developed, the liability to relapses is much more marked, and more or less permanent impairment of vision is extremely probable. The importance of prophylactic measures should be urged upon every patient. The affected individual should sleep alone, and should not use the same towels, pocket-handker-

chiefs, or wash-basins as are used by those around him.

*Treatment.*—The eyes should be kept free from discharge by the use of boric acid or other weak antiseptic solution. There is no specific or infallible cure for trachoma; indeed, its obstinate character is in no way better illustrated than by the enormous number of remedies that have been recommended for its treatment. In the acute onset or any of the acute exacerbations, the patient may be made more comfortable by any of the palliative measures recommended for other acute forms of conjunctivitis, such as hot or cold applications, cleansing and mildly astringent collyria, and atropine cycloplegia. It is necessary to remember that in this as in other diseases the patient's powers of resistance may be increased by proper attention to diet, fresh air, and rest, and by freely emptying the bowel.

The local reaction can often be considerably diminished by applying every day or two to the everted lids a one or two per cent. solution of nitrate of silver. The same preparation is often used regularly during the stage of lymphoid hypertrophy. For this stage, also, argyrol, protargol, flushing with a solution of permanganate of potassium, preparations of iodine, collyria of formalin (1:3000) and of bichloride of mercury (1:5000), and a solution of tannin in glycerin, have been recommended. The crystal of sulphate of copper, or blue-stone, has long been a favorite for cases where the discharge is not abundant. The crystal should be smooth, and should be thoroughly rubbed over the whole of the inner surface of the lids and the conjunctiva of the transitional folds. The remedy is a painful one, and in sensitive patients its application may very well be preceded by cocainization. Copper sulphate is also used in the form of a one to five per cent. solution in glycerin, applied to the conjunctiva with a cotton swab.

Good results are reported from the electrolytic introduction of copper sulphate into the conjunctiva, also spoken of as iontophoresis. A copper electrode of suitable shape is wrapped with a thin layer of absorbent cotton, which is soaked in a weak solution of the copper salt. The patient's hand is immersed in a basin of water (preferably a weak salt or soda solution) containing the negative electrode, and the positive pole is applied inside the lid and well into the cul-de-sac. Each part of the surface treated receives from three to seven or eight milliamperes of current for several minutes. The duration and strength of the application must be to some extent dependent upon the patient's powers of endurance, as the treatment is somewhat painful. Preliminary cocainization renders the treatment somewhat more tolerable. The intervals between successive sittings depend upon the reaction produced, but will commonly vary between one and two weeks.

Mayou has particularly recommended the *x*-ray treatment of trachoma. He seats the patient nine inches from the anode, uses a tube having a spark-gap of four inches and a current of six amperes, gives a four-minute exposure daily for six successive days, and if the reaction is not severe after a week's rest, continues the treatments several times a week until a slight reaction is apparent. Radium has also been employed. In either method a lead mask may be required to protect the face.

The use of massage with cotton soaked in oxycyanide of mercury, 1:1000 solution, is recommended by Axenfeld for the milder cases. A cotton swab which has been dipped in the solution and then gently pressed between the fingers is rubbed rather vigorously over the everted lids, which have previously been cocainized. The method is said to have the advantage that it rapidly cures follicular conjunctivitis, and so serves as a therapeutic test when doubt exists as to the diagnosis between that condition and trachoma. Massage with a cotton swab dipped in powders of boric acid, iodoform, iodol, aristol, or calomel, and massage with a plain glass rod, have also been recommended.

The most successful methods of treating trachoma seem in general to have been those which hastened the natural process of cure by promoting cicatrization of the lymphoid tissue. To this order probably belong the blue-stone, the electrolytic, and the *x*-ray treatment. Several of the operative methods applied to trachoma have for their object either the rupture or the expression of the trachoma follicles. In its simplest form, expression was done by compressing the conjunctiva between the thumb-nails of the operator. For the same purpose were devised Knapp's roller forceps and Kuhnt's expressor. The former consists of a forceps having two U-shaped blades carrying small grooved rollers between which the conjunctiva is squeezed and rolled. The second instrument has two flat blades, one corrugated and the other fenestrated with small holes, and is used in the same manner, except that the tissues are virtually scraped instead of being rolled. In either case, the operator must aim at reaching the whole of the affected tissues, and before either instrument is applied the lid should be everted, so that neither blade is applied to the skin but both to conjunctiva. The after treatment includes applications of a solution of silver nitrate or copper sulphate. Coover has devised what is probably the most effective and least destructive of the various operations included under the name of *grattage* or scraping. This consists of scarifying the diseased conjunctiva with fine sand-paper (No. 0 or 00), which may be sterilized in formaldehyde vapor or with alcohol which is removed by combustion. The piece of sand-paper is rolled upon the end of the finger, and the granulations vigorously rubbed down. The lid must be thoroughly everted, and this is done by seizing it at the edge with a forceps resembling an ordinary hemostatic forceps, but one blade of which carries two sharp points which fit into small holes in the other blade. For children a general anesthetic is necessary. The postoperative reaction is less than after the operation with Knapp's roller forceps. The operations rendered necessary by the deforming late results of trachoma will be found under *Eyelids*. Kuhnt practises excision of a part of the upper tarsus in old chronic cases with thickening of the tarsus, but the operation has not come into general use.

While some cases of trachoma yield to treatment after a few months, or more rarely after a few weeks, very many cases need more or less intermittent attention for years. Without exception, whatever the treatment used, there is no certainty of prognosis, and no security against relapse after the case is apparently cured.

Pinguecula.—This unimportant condition develops especially in persons, usually at or beyond middle life, who have been much exposed to strong wind, heat, light, and dust. It consists of a small elevation two or three millimeters in diameter, situated in the horizontal meridian of the eye a short distance from the corneal limbus, and commonly to the nasal side, although it may appear on both sides of the same eye. By Fuchs it is treated as an early stage of pterygium. It was formerly regarded as a fatty growth, but really consists of hyaline substance produced from the connective tissue of the conjunctiva, together with some elastic fibers. If necessary, it may readily be excised.

Pterygium.—This very characteristic condition was so called by the Greeks on account of its resemblance to an insect's wing. It consists of a triangular vascular hypertrophy of the bulbar conjunctiva, the base of which is toward the inner canthus and the apex on the cornea. It develops, like pinguecula, in persons much exposed to strong light, heat, dust, and wind, and according to Fuchs always arises from the condition mentioned. It occurs sometimes in young people, but usually in later life. The more vascular

the growth, the more rapid its advance. Pale pterygia tend to be stationary or to advance slowly.

The presence of a pterygium, apart from the disfigurement which it causes, is usually accompanied by ocular discomfort and some discharge. Its only serious aspect, however, is its tendency, if progressive, sooner or later to invade the pupillary area of the cornea, and so interfere with vision. The apex of the growth is preceded by a narrow border of cloudiness in the corneal tissue. The apex or head is structurally connected with the substantia propria of the cornea, and hence not only is it necessary to shave the head from the cornea as cleanly as possible in removing the growth, but even after this has been done some slight permanent opacity of the cornea in this region always remains. Pterygium which has developed well on to the cornea is sometimes accompanied by a marked astigmatism due to change in the curvature of the cornea.

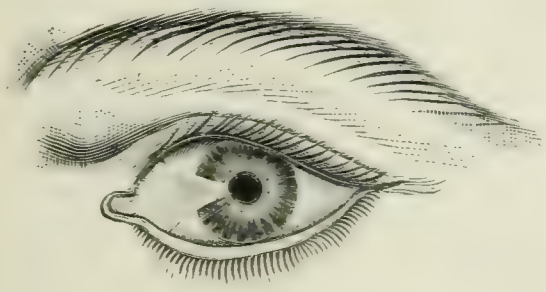

Fig. 1527.—Pterygium.

Pseudopterygium consists of a band of adhesion between the cornea and conjunctiva, resulting from burns or ulcers of the cornea. This may occur at any part of the circumference of the cornea, its apex is likely to be less regular than that of real pterygium, and the growth does not advance beyond the site of the original corneal disturbance.

*Treatment.*—Small, stationary pterygia do not necessarily call for removal, although this will sometimes be demanded by the patient for purely cosmetic reasons. Ligation was formerly used, but is unsatisfactory. Where the growth is very large, it is sometimes necessary to excise the hypertrophied tissue and replace the defect in the conjunctiva with a graft from the mucous membrane of the lip. Usually, however, the operation of transplantation will give the most satisfactory results. With a sharp knife, the head of the pterygium is cleanly shaved from the cornea, working from the side of the normal cornea. Or the neck of the pterygium may be transfixed close to the sclera back of the limbus, and the head removed by a sawing movement toward the clear cornea. According to Knapp's method the body of the pterygium is then dissected free from the sclera and the neighboring conjunctiva back as far as the caruncle. An incision is made in the ocular conjunctiva, beginning at about four millimeters from the cornea, and extending downward and outward from the site of the pterygium. This incision is made long enough to receive the transplanted pterygium, which is fixed in place by means of a suture passing through the apex of the growth and that of the conjunctival incision. Any remaining defects in the conjunctiva are now covered by sutures.

McReynolds' modification of the transplantation operation avoids the incision in the lower conjunctiva. After separating the head of the pterygium, a vertical incision is made, beginning at the limbus at the upper margin of the growth, and extending upward in the conjunctiva. The conjunctiva is then split back toward the caruncle along the lower margin of the growth, after which the pterygium, and the conjunctiva above and below, are freely undermined from the sclera. A suture threaded on two needles is passed through the head of the pterygium, and each of these needles is carried well down into the subconjunctival space in the vertical meridian at the lower part of the eyeball, and passed outward through the conjunctiva. The head of the pterygium having been drawn thoroughly down into this position, the suture is tied. The operation by this method has the advantages that, if neatly done, only one suture is needed and the sclera is nowhere left uncovered by conjunctiva. The vessels whose excessive blood supply has favored further encroachment on the cornea are given a perfectly harmless direction; and in the rare chance of a recurrence after this technique has been used, a further operation is not likely to be interfered with by cicatricial tissue.

When excision is selected, the conjunctiva must be well undermined above and below, and the edges brought together by sutures to cover the defect left by removal of the growth. It has also been advised to tear the head of the pterygium from the cornea (avulsion) by means of a strabismus hook. Whatever method is used, postoperative restoration of the eye to an approximately normal appearance (at least in the estimation of patients who are particular about their appearance) is likely to be a rather long-drawn-out process. The patient should be warned that the site of the operation is likely to be occupied for some time by enlarged blood-vessels. A number of slight modifications in the technique of pterygium removal or transplantation have been described, but their differences are unessential.

Acute inflammation of pterygium sometimes occurs. It is in the nature of a mild catarrhal conjunctivitis, and is to be treated as such. Eyes which have well-developed pterygia are frequently also affected by a chronic conjunctivitis.

Syphilis of the Conjunctiva.—Primary syphilitic sores are more apt to occur inside the lower lid and at the inner canthus. They do not differ from similar lesions on mucous surfaces elsewhere. Gumma is very rare, although a tertiary ulcer sometimes occurs on the conjunctiva which is liable to be mistaken for cancer on account of its chronicity and marked infiltrative character. The secondaries may affect any part of the conjunctiva. During the secondary stage also, weakly patients may have a catarrhal conjunctivitis which is not cured by ordinary measures but yields to the general systemic treatment.

Tuberculosis of the Conjunctiva.—Primary tuberculosis of the conjunctiva is very rare. It is quite doubtful whether the tubercle bacillus has the power to penetrate intact epithelium, so that an injury to the epithelium probably precedes primary tubercle. Such an infection runs a rather acute course at the start, although chronic in its later character. The miliary tubercles may suggest the follicles of trachoma, although tending to be reddish or yellowish-gray in color. The lids are somewhat swollen, and there is a moderate amount of mucopurulent secretion. The cornea may become affected, with resulting loss of vision. This form of the disease is monocular, and the lymphatics of the affected side will be found enlarged.

Secondary tuberculosis of the conjunctiva is sometimes secondary to lesions in the nose or larynx. It runs a chronic course from the start. It is described as occurring in three more or less distinct forms: (1) as small caseating ulcers; (2) as outgrowths of granulation tissue; and (3) as cockscomb-like excrescences. In any case of suspected tuberculosis of the conjunctiva the aid of the microscope should be invoked to determine the diagnosis; although it may be impossible to discover the bacilli in the tuberculous tissue. In the latter event, resort should be had to

animal inoculation. Or reliance may be placed on local reaction to a general tuberculin test.

Complete excision of the diseased tissue has usually been recommended. But considering the usually slow development of the local disease, tuberculin should be tried in selected cases. Ulcers may be destroyed by the galvanocautery. Successful results have been reported from the use of the *x*-ray and the Finsen rays.

Lupus of the Conjunctiva.—This may occur primarily or by extension from adjacent parts. It appears as granulations upon an ulcerated base, and like lupus elsewhere, tends to heal in one area while actively extending to another.

Parinaud's Conjunctivitis.—This rare disease, first described by Parinaud in 1889, is characterized by sharp local symptoms, involvement of the neighboring lymphatic glands, and an initial systemic reaction. Locally the lids are swollen, the bulbar conjunctiva is edematous, there is moderate mucopurulent discharge, and the characteristic conjunctival lesion consists of reddish polypoid vegetations, small yellowish granules, and superficial ulcers. The preauricular glands are usually enlarged, and less frequently the submaxillary, parotid, and cervical. The duration of the disease has been reported as from one to five months. In nearly all the cases one eye only was affected. The glands may suppurate. The tendency is to recovery. The etiology of the disease is still unknown, although recently Krusius and Clausen, Möllers, and others have argued strongly for a tuberculous basis. There is certainly a good deal of similarity between the local manifestations of cases of Parinaud's conjunctivitis and some of those definitely regarded as tuberculosis of the conjunctiva.

With the possible exception of excision of the granulations, no form of treatment has any marked influence on the duration of the disease.

Leprosy of the Conjunctiva.—In leprosy the conjunctiva may be anesthetic and inflamed, may develop an irregular form of pterygium, or may present leprous nodules, especially at the corneal limbus. The disease is usually secondary to lesions in other parts of the body. Leprous tubercle of the conjunctiva has been mistaken for sarcoma.

Tumors of the Conjunctiva.—The conjunctiva may be the seat of retention, lymphatic, traumatic, parasitic, and congenital cysts. Retention cysts are due to obstruction of the outlets of the so-called Henle's and Krause's glands, or of pseudoglands formed during inflammatory processes. Cysts beneath the conjunctiva toward the outer end of the upper lid may arise from the accessory lacrymal gland. Traumatic cysts are commonly derived from epithelial cells which have been incarcerated within the lips of surgical or accidental wounds of the conjunctiva. Cysticercus is the most frequent cause of parasitic cysts. The head may be visible as a white spot at some part of the cyst. Dermoepithelioma is a semitranslucent growth of congenital origin, situated near the corneal margin. Other benign tumors of the conjunctiva are fibroma, lipoma, osteoma, adenoma, angioma, and papilloma. The dermoids, which oftenest appear at the corneal limbus, contain various structures of the skin, including hair and glands. Xanthoma of the bulbar conjunctiva is occasionally seen. Nævus of the bulbar conjunctiva, as elsewhere, has in a few instances shown a tendency to sarcomatous degeneration. The malignant growths, epithelioma and sarcoma, grow most frequently at the limbus. If they are removed early and the eyeball has not become involved, it may be possible to save the eye. Otherwise the eyeball should be removed, even though the sight of it is still good.

Injuries to the Conjunctiva.—*Foreign bodies* entering the conjunctival sac are usually soon washed down into the lower cul-de-sac or to the inner canthus. If lodged on the conjunctiva of the upper lid, they are most frequently to be found about the middle of the upper border of the everted tarsal cartilage. Rarely, they may lodge in the upper cul-de-sac, Removal of foreign bodies from the surface of the conjunctiva calls for cocainization only when the object is so firmly embedded that it is necessary to displace it with a needle or spud. Deeply embedded grains of powder produce no irritation after the wound of entrance is healed.

*Burns* of the conjunctiva may be due to the direct application of heat, as in conflagrations, from bursts of flame, or from boiling water or molten metal. Or they may be due to chemical caustics, whether acids, alkalies, or other substances. The tissue destruction connected with burning causes rapid edema of the surrounding parts. When the injury is deep or extensive, serious adhesions between the ocular and palpebral surfaces are likely to develop, and the movements of the lids and eyeballs may be greatly interfered with.

Thermal burns should be treated by placing bland oils or vaseline in the conjunctival sac at frequent intervals. Splashes of metal should be thoroughly removed. Any remaining acid should be neutralized by means of a weak solution of bicarbonate of sodium or other alkali. For lime burns, after particles of lime or mortar have been removed, Weeks recommends dropping into the eye a simple syrup, which forms an insoluble compound with the lime. After the preliminaries mentioned, oil may in every instance be used for subsequent dressing of the eye. Where the burn is severe, symblepharon is likely to develop in spite of all efforts to the contrary. But attempts should be made to keep raw surfaces apart, by daily separating them with a probe, or by keeping between them pledgets of cotton dipped in oil, or by the patient's wearing a glass or leaden shell until healing has occurred. Deformities of the lids, however, are liable to result from cicatricial contraction as well as from adhesions.

Pemphigus.—This very rare disease may involve the conjunctiva. After the repeated formation and breaking of bullæ, the subconjunctival tissue slowly undergoes cicatricial changes, until in the course of years the conjunctival sacs are obliterated. No form of treatment arrests the progress of the disease. If a stationary condition appears to have been arrived at, an attempt may be made to restore the conjunctival sac by plastic measures.

Xerophthalmus (Xerosis).—There is no etiological connection between this disease and the xerosis bacillus, although that organism is commonly found in large numbers in the greasy deposit which covers the altered tissues. Anatomically the disease consists of a degenerative change in the epithelium. This may be secondary to trachoma and other diseases involving the deeper conjunctival tissues, or may develop primarily in marasmic children or poorly nourished adults. In the latter its typical form is that of a "dry patch" on the conjunctiva close to the cornea, in shape triangular with the base toward the cornea. Night blindness is sometimes present.

Amyloid Degeneration of the Conjunctiva.—The connection of this rare condition with trachoma has been maintained and denied. It appears as pale, yellowish, amyloid deposits, larger than trachoma granules, beneath the epithelial surface.

Conjunctivitis Petrificans.—This rare disease was described by Leber in 1895. It has been observed exclusively in women, and consists of slightly raised plaques covered with epithelium. The deposit is an organic compound of lime.

Concretions in the Conjunctiva.—These are accumulations, the size of a pin-head, of cheesy material

in the glands of the mucosa. They may undergo calcareous change and come to act as foreign bodies, in which event they should be turned out with the point of a needle.

Argyria.—Just as the long continued internal administration of silver compounds may produce a general staining of the subepithelial tissues of the body, so prolonged use of silver salts in the eye is liable to result in a local discoloration of the mucous membrane. For this reason patients should not be left to instill at home over indefinite periods solutions of the organic silver compounds. It has been stated that dionin diminishes the stain. It is the underlying elastic fibers, and not the epithelial cells, in which the stain resides.

Siderosis.—A yellowish-brown discoloration of the conjunctiva has been reported as due to the prolonged use of a collyrium of sulphate of iron.

Subconjunctival Ecchymosis.—This has no serious import. It may occur in purpura hemorrhagica, or as the result of violent straining. It is rather frequent in children with whooping cough. A month or more may elapse before the blood entirely disappears, although the process may be hastened somewhat by bathing with hot water.

Chemosis is the term applied to great edema of the conjunctiva. It is usually secondary to local disease, but may occasionally appear suddenly without apparent cause, when it is known as angioneurotic edema. It may be reduced by scarification if necessary.

Emphysema.—The occurrence of this condition in the conjunctiva is most frequently due to fracture of the lacrymal bone. It sometimes results from violent blowing of the nose, especially when the bony wall has been weakened by disease of the ethmoidal sinuses.

Lymphangiectasis.—This appears as small transparent vesicles in the bulbar conjunctiva. The vesicles are irregular in shape and freely movable. Their formation is due to obstruction of the lymph stream. They may be treated by excision or by galvanocauterization, although spontaneous disappearance is the rule.

Affections of the Caruncle.—The caruncle often shows quite marked redness and swelling in cases of otherwise mild conjunctival irritation due to eyestrain. It is occasionally the seat of abscess. It may become a focus of irritation in consequence of excessive development of the rudimentary hairs normally present. Adenoma, sarcoma, epithelioma, nævi, and other tumors have been described as arising in the caruncle.

William H. Crisp.

**Connective Tissues.**—The connective tissues constitute the supportive tissues of the body and are derived from the mesoderm. They connect the various organs and structures together and fill in what ordinarily would be spaces. Tissues consist of cells and intercellular substance. Connective tissues are characterized by the fact that the intercellular substance predominates; the latter varies in consistency through a wide range from the liquor sanguinis of the blood and the soft fibrous material of the areolar and elastic forms to the harder cartilage, bone and dentine. The vascularity varies also, some varieties having few vessels, while others are quite vascular.

All the connective tissues are derived from the mesenchymal portion of the mesoderm. From this mesenchyme are differentiated the various varieties and most of the stages in this differentiation are readily followed. They are often found to replace one another and this gradual transition shows the close relation existing between the varieties. The affinity between the fibrous forms is more marked than between these and the modified varieties, as cartilage, bone, dentine, and adipose tissue. This difference is due to the different functions of the various forms.

The *varieties* of connective tissue are as follows: *Fibrous:* (1) areolar, (2) white fibrous, (3) yellow elastic, (4) mucous, (5) retiform. *Modified:* (6) lymphoid, (7) adipose, (8) cartilage, (9) bone, (10) dentine, (11) blood.

1. Areolar tissue is a delicate, web-like form representing the most widely diffused variety. It consists of an interlacement of the yellow elastic and

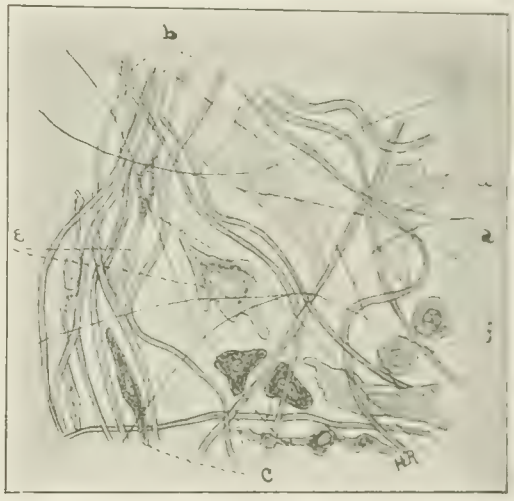


Fig. 1528.—Areolar Tissue. *a*, Lamellar cell; *b*, white fibers; *c*, plasma cells; *d*, elastic fibers; *e*, elastic cells.

white fibers and various cellular elements. It is called such because the fibers interlace to form areolæ or lymph spaces that communicate with one another thus allowing liquids to diffuse over a great distance. These spaces vary in size in different portions of the body. This tissue varies somewhat in different regions and in different animals, being somewhat tougher in man. It is found binding the skin to the fascia beneath, as intermuscular septa, surrounds blood-vessels, nerves, and lymph channels, and assists in the formation of most of the organs of the body.

The cellular elements comprise *lamellar cells, clasmocytes, plasma cells, wandering cells,* and *pigmented cells.*

The *lamellar cells* are the chief cells and are usually flattened stellate elements the processes of which may anastomose with those of other cells. The protoplasm is usually clear, but a few granules may be present. The nucleus is oval. These cells are the only ones present in some varieties of connective tissue. The younger elements are round and spindle-shaped, gradually developing more processes until the branched cell is formed. In some places, as the eyeball, these stellate cells are pigmented. The pigment, *melanin,* is restricted to the cytoplasm. In the skin of the frog, pigment cells are numerous and the color of the skin can be varied by the distribution of the pigment in the pseudopodia of the cells. This is due to the ameboid motion of the cells as shown by Verworn in 1909. In some regions as the large lymph spaces, the lamellar cells are flat and plate-like and constitute here the endothelial cells.

The *clasmocytes* are irregular elongated elements that are probably derived from the wandering cells.

The protoplasm is granular and may show vacuoles, while the nucleus is large and oval in form.

The *plasma cells* are flattened, elongated, or spheroidal elements that may show branches. The protoplasm contains some vacuoles and a number of basophilic granules. The nucleus is usually small and excentrically placed. These cells are most numerous in blood-forming and lymphoid organs.

The *wandering cells* are leucocytes that have wandered in from the blood.

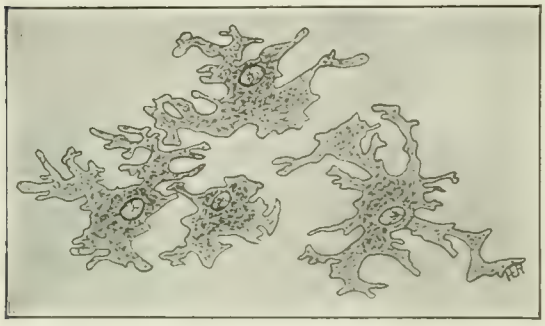

Fig. 1529.—Pigmented Connective-tissue Cells from the Web of a Frog's Foot.

*Mast cells* are large round cells in which the protoplasm contains a large number of basophilic granules. These are found chiefly in bone marrow and regions where fat is being deposited. They are probably modified leucocytes.

The *intercellular substance* is soft and fibrillar in character. The *white fibers* consist of delicate bundles of fibrils, some of which pass from one bundle to another. The fibers run in wavy bundles that interlace with one another and with the yellow elastic fibers.

The *elastic fibers* are yellow in color and branch. They are not arranged in bundles and have a straight course. They are usually heavier than the white fibers.

2. White fibrous connective tissue is that form in which the fiber bundles do not interlace, but run mainly parallel to one another. It is white, shining,

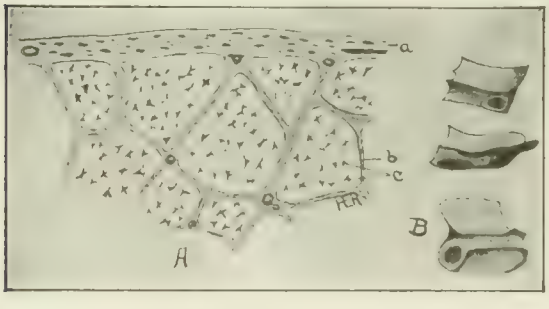


Fig. 1530.—*A*, Cross-section of a tendon; *a*, epitendineum; *b*, peritendineum; *c*, tendon-cells cut transversely. *B*, Isolated tendon-cells.

tough, and yet pliant. This form is found in fasciæ, dura, and tendons. In *fasciæ*, or *aponeuroses*, the fiber bundles run transversely and longitudinally, but do not interlace. Those of each plane run parallel to one another. In the *dura*, the bundles take different directions and decussate with one another, forming a dense unyielding membrane. In *tendons* the bundles are all practically parallel to one another. This arrangement is of the greatest importance in surgery, as it permits of *tendon-splicing*. The structure is characteristic. Each tendon is surrounded by a sheath of white fibrous tissue called the *epitendineum;* this sends in septa that divide the structure into secondary bundles that are further divided by other sheaths (*peritendineal*) into primary bundles within which are the bundle of tendon fibers. Between these fiber bundles lie the *tendon cells*. These are quadrilateral upon surface view, but upon cross-section tend to a stellate form due to pressure of the fiber bundles.

White fibrous tissue yields *gelatin* upon boiling. The fibers dissolve in gastric juice and swell when treated with dilute acids. They do not dissolve readily in pancreatic juice. Van Gieson's stain is a special stain for this variety.

3. Yellow elastic tissue is so called from its color and its elastic property. Its rubber-like character is required in certain regions. It is found in areolar tissue mixed with the white fibrous form, but in a purer state in *ligamentum nuchæ*, *ligamenta subflava*, and certain other ligaments, and in the *elastic laminæ* of blood-vessels. In the ligaments the fibers are heavy and coarse and run parallel to one another. They are bound together by white fibrous tissue. These ligaments are not as strong as those composed entirely of white fibrous tissue and will break when forcibly stretched. Upon rupture the ends of the fibers curl. In the blood-vessels the elastic tissue is mixed with white fibrous on the one hand and on the other arranged in the form of *laminæ* and *elastic membranes*. In the large arteries the fibers form a prominent *fenestrated membrane*.

Fig. 1531.—Elastic Fibers from Ligamenta Subflava.

Elastic tissue yields *elastin* upon boiling. The fibers do not swell in dilute acid, nor do they digest readily in gastric juice, but are digested by pancreatic juice. Special stains are Weigert's elastic and orcein stains.

White fibrous and elastic tissues are poorly supplied with blood-vessels and nerves, but richly supplied with lymphatics. The origin of the white and yellow fibers is still in dispute. According to Waldeyer, Fleming, and Meves (1910), the fibers are formed with the cell by the direct conversion of the exoplasm or processes into fibrillæ. According to Kolliker, Ranvier, and Merkel (1909) both fibers are formed in the homogeneous intercellular substance by secretions from the cells and not by a direct change of the protoplasm. Mall regards the intercellular matrix as exoplasm and the endoplasm is the cells and connecting processes. He regards the exoplasm as living substance and in this the fibrils develop. M. Heidenhain holds a similar view.

4. Mucous or embryonic connective tissue represents the mesenchyme before the differentiation into the other forms. It is best seen in young embryos and umbilical cord and in the adult is represented in the vitreous humor of the eyeball and the pulp of the teeth.

The cells are very numerous and round at first and may exhibit ameboid movement. Gradually they become spindle-shaped and then somewhat stellate, the various processes of the different cells uniting to

make a *syncytium*. In these changes the cells become more widely separated and the intercellular spaces are filled with a homogeneous jelly-like substance called the matrix. The cellular elements vary in

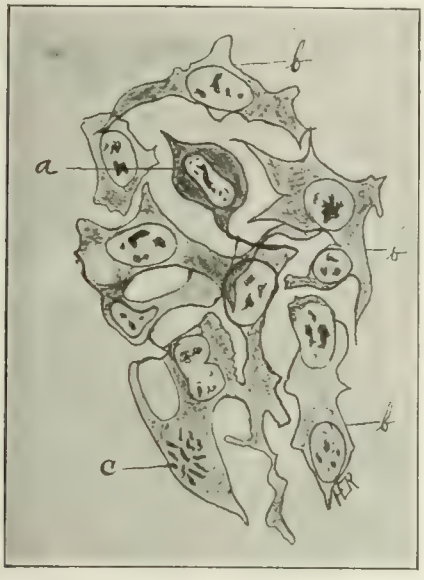


Fig. 1532.—Mesodermal Cells Uniting to Form a Syncytium. (After Maximow.) *a*, Lymphocyte; *b*, ordinary mesodermal cells; *c*, cell showing karyokinesis.

number according to the variety of tissue to be formed. In the vitreous humor and umbilical cord these cells are few in number. The younger cells possess little cytoplasm and the nuclei little chromatin. As the cells change the protoplasm becomes more

Fig. 1533.—Section of the Umbilical Cord at Birth, Showing Some of the Cells.

abundant and granular and forms processes. The nucleus contains chromatin and karyokinetic figures are often seen. The further changes depend upon the variety of tissue to be formed.

5. Reticulum or retiform connective tissue is that variety that constitutes the framework of glands and gland-like organs. Within the lobules of these organs it forms a very close network of delicate fibrils that supports the parenchyma, vessels, nerves, and lymphatics. These fibrils closely resemble the white fibers of areolar tissue. In lymphoid tissue lamellar cells are applied to the strands of the network. These cells, however, do not form the network. According to Mall, the tissue yields reticulum and not gelatine upon boiling, but later investigation seems to confirm the fact that reticulum is simply a special arrangement of white fibrous tissue. Reticulum may be well brought out by the use of Mallory's reticulum stain.

6. Lymphoid tissue consists of a network of reticulum supporting the lymph cells or in reality certain of the leucocytes, the lymphocytes, and hyalin cells. It is found *diffuse* in the mucosa of the alimentary, respiratory, and genito-urinary tracts, the spleen, thymus, and tonsil. Here the leucocytes are evenly scattered with no arrangement into definite masses. *Solitary nodules* are found in the above places with the exception of the thymus body. In this variety the leucocytes are collected into definitely circumscribed masses, round or oval in form. Each consists of a network of reticulum supporting the leucocytes and vessels. *Peyer's patches* or *aggregated solitary nodules* are found in the ileum and consist of ten to sixty solitary nodules in one mass. Each patch is about two centimeters long and oval in shape, with the long axis parallel to the long axis of the bowel.

The *lymph node*, or *gland* is a bean-shaped organ varying in size from the head of a pin to a lima bean. They are usually grouped and lie in the pathways of the lymphatic channels and thereby filter the lymph. The spleen, thymus body, and tonsils will be considered in other places.

1. Adipose tissue, or fat, is widely distributed and is found in most of the places where areolar tissue is

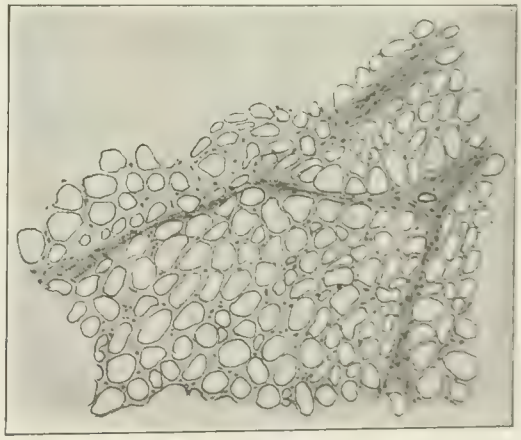

Fig. 1534.—Section of Adipose Tissue; ordinary preparation.

seen. It is more abundant in certain parts of the body than in others, as around the kidneys and beneath the skin as the *panniculus adiposus*. It is also seen in the furrows of the heart and beneath or between the layers of serous membranes as the mesentery and great omentum. Around joints it fills in spaces and in yellow bone marrow it constitutes the bulk of that tissue. It is absent from the penis, scrotum, eyelids, lungs, and cranial cavity. Fat represents a storage of nutritious material as well as protective structure.

Under the microscope ordinary preparations of

adipose tissue resemble a network in which the meshes are all small and fairly uniform in size and shape. The fat cells measure 0.034 millimeters to 0.13 millimeters in diameter and when few in number are seen in smaller or larger clusters. The fatty substance itself is gone. At the corners of these spaces are seen small crescentic masses of protoplasm containing nuclei. These masses represent the remains of the cytoplasm after the storage of fat. If fat be fixed in osmic acid, it is then practically insoluble in the various reagents and remains intact. Then an individual fat cell is seen as a black circular mass averaging 40 to 80 $\mu$ in diameter. Each consists of a delicate membrane surrounding the oily substance which is liquid at the body temperature. The membrane is very thin and when apparently invisible in ordinary preparations

Fig. 1535.—Section of Fat Fixed in Osmic-acid Solution. The clear vesicles indicate where the fat drop has been removed.

may be shown by Ranvier's method. This consists in an interstitial injection of silver nitrate solution (1–1000); this causes the protoplasm to swell forming a distinct rim about the contained fat. After death, *margarin crystals* may form in this fat. These fat cells when numerous are collected into lobular masses that are surrounded by a delicate membrane. Such oval, or ball-like masses are attached to a pedicle and are seen best in dissections of the sole and palm. These lobules are collected into masses of various sizes. As fat is deposited in areolar tissue this tissue forms the sheath that surrounds the lobules and lobes and supports the vessels and lymphatics that are present in the fat. The blood-vessels are quite numerous and the larger trunks lie in the interlobular tissue while the capillaries form an abundant and fine network in the lobules. The lymphatics are numerous and accompany the blood-vessels. Sensor nerves are absent, but nerves for the vessels are present.

According to some writers, fat cells are merely connective-tissue cells that act temporarily as depositories for fat. According to E. F. Bell (1909) the deposition of fat is preceded by the appearance of a peculiar open network in the areolar tissue with branched cells. This he called *pre-adipose tissue.* Preceding or accompanying the deposition of fat, there is a formation of a rich capillary plexus. According to others, the fat cells are special cells. In the fetus, even before the deposition of fat occurs, gland-like cells are seen about the kidney and these have been called the *fat organ.* The formation of pre-adipose tissue is true of most fat as the appearance is never glandular and when fat is removed by starvation, the cells return to the ordinary connective-tissue type. Fat first appears during the fourteenth week of intrauterine life in the form of minute granules in certain connective-tissue cells. These droplets gradually increase in size and run together at the expense of the protoplasm to form a single drop, pushing the cytoplasm and nucleus to one side. By the end of the fifth month the fat cells begin to form lobules. At first while the fat cells are few in number, they are spherical in shape, as they increase and become packed, they gradually become polyhedral in form. Mast cells are very numerous where fat is being deposited and are said to be concerned in the formation of the fat. According to Hammar and Flemming fat deposition occurs only in the lamellar and plasma cells. When fat is removed from the cell, the protoplasm increases. It is peculiar in appearance and does not respond readily to the stain. These cells have the appearance of the ordinary connective-tissue cell and are called *atrophic,* or *serous fat cells.*

Fat droplets may be found normally in many cells beside adipose tissue. They are to be found in the cells of the liver, intestine, adrenal, cartilage, and even muscle. In muscles the droplets are sometimes of a lipoid character and are not true fat. In these cells the fat is independent of the condition of nutrition and does not constitute fatty tissue.

In hibernating animals considerable masses of fat begin to collect between the kidneys toward autumn. This fat serves, no doubt, as a store of fuel and food during the winter while the animal sleeps. This is called the *hibernating gland.*

Fat responds to special stains as osmic acid, Sudan III, and cyanin. H. E. Radasch.

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**Conorhinus.**—The genus to which the bug known as the "blood-sucking cone-nose," *C. sanguisugus,* belongs. This bug is gray in color with bands on the sides of the abdomen, reaches the length of three-quarters of an inch and ranges from the Ohio River southward. It hides in beds or even bites through clothing and inflicts severe wounds which fester and discharge pus for several days. See *Insects, poisonous.* A. S. P.

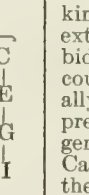
**Consanguinity.**—This term denotes blood relationship, and is to be distinguished from affinity, which signifies relationship by marriage. The husband bears the same relation to certain individuals by affinity that the wife bears by consanguinity. But two persons, each related to a third person by affinity, have thereby no affinity for each other.

The principal importance, from a medical point of view, of the subject of consanguinity is in the effect produced upon offspring by the fact of such a relation existing between the parents. In part from a belief in the injurious effects upon offspring of marriages between near kin, in part from the influence of authority, and in part from a natural repugnance to such unions, legal prohibitions have been placed in many countries upon marriages between persons who are within certain specified degrees of consanguinity. In some instances these restrictions have been extended from the field of consanguinity to that of affinity. In England, for example, for 200 years it was illegal for a man to marry his deceased

wife's sister, a relation obviously not within the bounds of consanguinity at all.

Consanguinity may be either lineal or collateral. The former is reckoned between persons in the direct line of descent, either downward from progenitor to descendant, or upward from descendant to progenitor. Collateral consanguinity exists between two persons descended, not the one from the other, but both from some common ancestor. The degree of consanguinity is measured in the first instance by the number of generations separating the two individuals. Thus grandfather and grandchild are in the second degree of lineal or direct consanguinity. In defining the degree of collateral or indirect consanguinity two different methods have been used, which have given rise to some confusion. By the civil law the degree is measured by counting the number of generations upward from one individual to the common ancestor, and thence downward to the other. By the canon law the number of degrees are counted only in one line (that which is the longer of the two) from the common ancestor.

Thus, supposing F and G to be great-grand-children of A, and hence second cousins, as by the accompanying diagram, according to the civil law they would be in the sixth degree of consanguinity, while by the canon law they would be in the third. The imperfectness of the latter mode of reckoning is shown by the fact that G would also be in the same degree of consanguinity, viz., the third, to A, B, and D; but in the fourth degree to H, the count then being made in the other, or longer line. Evidently, a prohibition of marriages within the third degree, made by the civil law, would become much more onerous if interpreted in accordance with the canon law. This was actually done by Pope Gregory I. (A.D. 590–604).




Much diversity has prevailed among different nations in their views concerning the marriage of kin. The traditions of the ancient mythologies, in their account, for instance, of the relations between Jupiter and Juno, and between Osiris and Isis, show that unions in the closest collateral degrees of consanguinity were not considered abhorrent. On the other hand, the story of Œdipus and Jocasta indicates that marriages in the direct line of descent were looked upon as impious. The ancient Egyptians intermarried very closely, and in the history which we possess of the dynasty of the Ptolemies, a large proportion of the marriages are seen to be between brother and sister. In other nations of the East, notably among the Persians, marriage in the nearest degrees, even of direct consanguinity, prevailed. In fact, during the countless ages before the institution of marriage had evolved itself, casual sexual relations suggested by propinquity and therefore in a large degree among related persons were the means of the propagation of the race. Such unions have been common within historic times and doubtless still exist in certain quarters of the earth. There is evidence that prior at least to the time of Moses this custom prevailed among the children of Israel. This very nation was descended from consanguineous unions. Abraham married his half-sister, Sarah, Isaac married Rebecca, his first cousin once removed, and Jacob his two first cousins, Rachel and Leah. Yet no one has ever questioned the vigor of the Israelites, who, in the first fourteen generations from their origin, became 600,000 fighting men. The restrictions placed upon the marriage of relatives by the Mosaic law are worthy of special attention, because they have remained, to a great degree, in the usage of Christian nations in modern times. The following marriages were prohibited on the score of kinship by the Levitical law (Leviticus xviii.): That with a parent, or with a stepmother; with a sister, or half-sister; with a granddaughter; with an aunt, or an uncle's wife; with a son's wife; with a brother's wife; with a step-daughter, or a step-granddaughter; with a wife's sister, *during the lifetime* of the former. The Greeks, while forbidding marriages in the direct line of descent, permitted them between half-brothers and half-sisters; the Athenians allowing the marriages of brothers and sisters by the same father, but not of those by the same mother; and the Lacedæmoniars, on the other hand, allowing uterine brothers and sisters to marry, but not those having a common father—an obviously arbitrary distinction.

The Romans held still stricter views. Not only the direct line of consanguinity, as well as brothers and sisters, either in whole or in half, were excluded from intermarriage, but any union within the degree of first cousin was practically illegal, the occasional marriage of uncles with nieces in the times of the Tarquins and of the emperors being held to be a stretch of despotic authority. The Institutes of Justinian, the basis of the modern civil law, forbade marriages in the direct line, and in the collateral line within the fourth degree. First cousins and all remoter kin might marry. The Roman Catholic Church extended the restrictions, discouraging, and then forbidding unions between first cousins. Various councils in the early centuries altered the rules, usually in the direction of greater exclusiveness. The present canon law, that of the fourth Lateran (twelfth general) Council, A.D. 1215, in force in most Roman Catholic countries, permits marriages only outside the fourth degree, *i.e.* third cousins are forbidden to marry. The Church, however, reserves and exercises the power of allowing dispensation from this prohibition. The civil law permits marriage in the fourth (civil) degree, that is, allows first cousins to marry. The Greek Church allows third cousins to marry, but prohibits all nearer relations. In England the ecclesiastical prohibitions on this subject were at first even more stringent than those of the present canon law, but under Magna Charta they were modified so far as to admit marriage outside the fourth canonical degree.

The restrictions of the canon law were set aside in England by the Marriage Act of 1540, in the reign of Henry VIII., and the prohibitions of the civil law, practically the same as those of Leviticus, were substituted. Marriages may be made in the fourth and all remoter degrees, computed according to the civil law. Hence first cousins may marry, as may also nephew and great-aunt, or niece and great-uncle. Indeed, by the letter of the law, as has been pointed out, while a man may not marry his grandmother, he may marry her sister. This law affects England, Scotland, Ireland, and all the British colonies. It is worthy of remark in this connection that the prohibition of marriage with a deceased wife's sister, which is not Levitical, and which, in spite of an annual effort to remove it, is still maintained in the home country, has been removed in most of the British colonies.

In the various States of this country the degrees of consanguinity in which marriage is prohibited are practically those of the Levitical code. A few of the States, however, forbid by law the marriage of first cousins, and, on the other hand, in one or two, a man is allowed to wed his aunt or his niece.

The difficulties in the way of obtaining accurate knowledge as to the production of evil effects in offspring by consanguineous marriages are very great. In the first place, in the absence of State registration covering this point, people are apt to resent inquiries as impertinent. Especially is reluctance manifested if the children have any physical or mental defect. Secondly, upon persons who collect and record such cases among their own acquaintances, instances of evil results are liable to produce more effect than negative cases, which, presenting nothing of importance, drop out of notice, and the fact of consanguinity

on the part of the parents is quite forgotten. Thirdly, in some of the unfavorable cases collected, too little attention is paid to the moral elements of the case. For instance, in the family of the Ptolemies, where the intermarriages were very close, whatever may be claimed as to the physical degeneracy of the stock (and there seems to be very little ground for Mr. Francis Galton's remark as to its sterility) may be in considerable degree ascribed to the enervating physical and moral effects of unlimited despotic power. Other tabulated lists prepared to show the evil effects on offspring of marriages between relatives include unions nearer than the fourth degree. But close incestuous unions presuppose moral degradation, and this cannot fail to have its effect on the physique both of parents and of children. Some of the figures collected upon this subject have been obtainable only from records of public institutions, and are based, for the most part, only on the lowest classes of society. But where, as in the individuals included in Dr. Howe's statistics, "most of the parents were intemperate," it would evidently be unfair to conclude that the large percentage of idiots among the children was due entirely to the consanguinity of the parents, and not in large part to their intemperance. Again, accounts have been published of certain European communities, geographically isolated, where numerous consanguineous marriages have occurred. Granting that there is no moral obliquity in these individuals, there is certainly very little ambition or enterprise in men who are content to stagnate in the same spot where their ancestors have lived for generations, with no curiosity to learn what lies outside the borders of their hamlets. Fourthly, confusion exists between the effects of consanguinity and those of hereditary morbific transmission. Where two relatives wed, both of whom possess a similar disease or tendency to disease, the offspring are very likely to inherit the disease, the latent tendency even becoming a patent actuality. But this is the fault of the morbific strain multiplied into itself, and thus raised, as it were, to its second power, and not of the mere fact of consanguinity in the parents. For the same result would follow the union of two persons not related if they possessed some defect in common; and, on the other hand, in the breeding of animals, while the parents are blood relations, yet such care is taken to select perfect specimens that no chance is allowed for the propagation of a fault. This point, which is of great importance, will be again alluded to later on. Fifthly, and finally, it should be remembered that positive cases in which the marriage of relatives has been found to give numerous and perfectly healthy children are more significant and important than negative instances, where perfect children did not follow such unions. Because in the latter case the imperfection may have been due to other elements than the consanguinity, whereas, if the fact of consanguinity in the parents constitutes *per se* an obstacle to the propagation of healthy children, defective offspring should follow in all or nearly all cases wherever that bar to perfect offspring, to wit, consanguinity, existed in the parents.

With the above provisos as to the interpretation of statistics bearing upon this point, we will now examine some of these reported facts.

Dr. Bemiss ("Report on Influence of Marriages of Consanguinity upon Offspring," Transactions of the American Medical Association, 1858, vol. xi., p. 334) collected a large number of cases of marriage between relatives, which tell strongly against the safety of such unions. Eight hundred and thirty-three such marriages are reported, including cases of incest between parent and child, and brother and sister. The average number of births was 4.6. An extract from his table is given below. This table presents the case against consanguineous marriages with its full strength. Yet, as the author himself says: "It is natural for contributors to overlook many of the more fortunate results of family intermarriage, and furnish those followed by defective offspring or sterility." One other vulnerable point in these figures presents itself. Marriages between third cousins are much more productive of evil results in the offspring than marriages between second or even first cousins! In other words, the eighth degree of consanguinity, which is so remote that persons occupying it must often be ignorant that any kinship at all exists, really constitutes a greater danger to marriage than relationship in the fourth degree.

Dr. Mitchell's statistics ("Memorandum before the Anthropological Society of London," vol. ii., 1866, p. 403), also classical upon this point, are based upon 45 cases of consanguineous marriage. Eight couples were barren, and the remainder produced 146 children; an average of about 4 for each fertile marriage, or of 3 for all marriages, barren and fertile. Eight children were idiots, 5 imbecile, 11 insane, 2 epileptic, 4 paralytic, 2 deaf-mutes, 3 blind, 2 defective in vision, 3 deformed, 6 lame, 1 rachitic, 22 consumptive, scrofulous, or manifestly of weak constitution.

Dr. S. G. Howe's tables, computed from Massachusetts statistics (*Journal of Psychological Medicine and Mental Pathology*, July, 1858), have been already referred to. These marriages produced 95 children, an average of 5.5 each. Forty-four were idiots, 12 scrofulous, 1 deaf, and 1 a dwarf.

Huth, in the appendix of his work ("The Marriage of Near Kin"), from which some of the above observations have been taken, has gathered a series of 299 cases from many sources, a considerable portion being from writers who disapprove of consanguineous marriages. The catalogue of diseases referred to this cause is long, numbering nearly forty. The total children born were at least 1,155 (3.8 per marriage), and in eighty-three of the families there were no unhealthy children. The principal defects that have

| Classes of relationship | Number of observations. | Average number of births. | Defective, per cent | Deaf-mutes, per cent. | Blind, per cent. | Idiots, per cent. | Insane, per cent. | Epileptic, per cent | Scrofulous per cent | Deformed per cent | Died young, per cent. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Incest with parent, or between brother and sister | 10 | 3.10 | 93.5 | | | 61.2 | | 3.2 | 16.1 | 35.4 | |
| B. With niece or aunt | 12 | 4.42 | 75.4 | 1.9 | 5.6 | 5.6 | 1.9 | 1.9 | 20.7 | 26.4 | 43.3 |
| C. With blood relations the issue of blood relations. . | 56 | 4.18 | 53.8 | 4.2 | 5.1 | 12.8 | 1.2 | 1.7 | 18.8 | 3.8 | 26.9 |
| D. With double first cousins | 27 | 5.70 | 27.2 | 1.2 | 1.2 | 2.5 | 3.8 | 1.2 | 6.3 | 1.2 | 35.0 |
| E With first cousins | 580 | 4.80 | 24.9 | 4.2 | 2.2 | 8.3 | | 1.6 | 6 2 | 1.9 | 22.5 |
| F With second cousins | 112 | 4.58 | 13.0 | 1.7 | | 3.3 | | 1.1 | 2 9 | 1.7 | 16 5 |
| G With third cousins | 12 | 4.92 | 27.0 | 5.0 | | 1.7 | 1 7 | 3.4 | 16.9 | | 13.5 |
| H With first cousins, irregularly reported | 24 | 5.00 | 17.5 | 2.5 | | 2.5 | 1.6 | | 12 5 | | 10 0 |
| Total | 833 | 4.6 | 28.7 | 3.6 | 2.1 | 7.0 | 2.04 | 1.5 | 7.6 | 2.4 | 22.4 |
| Compare marriages with persons in no way related. . | 125 | 6.7 | 2.1 | 0.35 | 0.1 | 0.71 | 0.1 | 0.35 | 0.1 | | 6.0 |

been charged to such marriages by various authors and at different times are (*a*) deaf-mutism. Boudin claimed that while two per cent. of French marriages are consanguineous, 27 per cent. of deaf-mutes came from consanguineous unions. But G. Darwin found that among 366 congenital deaf-mutes in institutions in England, only eight were the children of consanguinity. (*b*) Retinitis pigmentosa. E. Schmidt quotes from a number of authors, *e.g.* Leber, eighteen cases of consanguineous descent among sixty cases of retinitis. On the other hand Penot (Thesis, Lyons) found this factor negative. (*c*) Sterility. Darwin thought there was a paucity of children in consanguineous marriages but Penot cites among 873 cousin marriages in the state of Ohio, the birth of 3,900 children. (*d*) Feeblemindedness and other forms of mental disease. The chief charges in this regard made against consanguinity resolve themselves into charges against heredity.

It will thus be seen that those who condemn consanguineous marriages *ipso facto* have presented a very extensive catalogue of charges. Those most generally dwelt upon have had relation to what may be called the social functions of the individual. As Guipon, representing this opinion, puts it (*Comptes Rendus*, vol. lvii., p. 513), "consanguinity exerts a depressing effect on the vital forces, notably upon reproduction, so that if sterility is not observed in consanguineous marriages themselves, it at least shows itself in their children. It affects the functions of relation and the organs of sense, hearing, speech, and sight. The genital sense is exalted, but its natural end and aim is thwarted."

On the other hand, numerous and reputable observers have reported many cases where consanguineous marriages were unattended by any degenerative conditions in the offspring. For example, we have an instance reported by M. Dally (*Anthrop. Review*, May, 1884, p. 95), where two families continually intermarried for five generations, no marriage being in a more distant degree than first cousins, except two of second cousins. The total number of branches direct and collateral was 120 to 140. There was not a single case of deaf-mutism or idiocy, but there were two cases of consumption, one "caused by a cold," and one case of senile insanity in a woman of sixty-eight. It should be remarked that there was no predisposition to disease in the family.

Perhaps the most striking instance on record of consanguineous marriages without ill effect upon offspring is furnished by M. Bourgeois (*Comptes Rendus*, vol. lvi., p. 178). The family in question is his own. A genealogical table is given covering seven generations. In one branch of the family, of five successive generations four married their cousins, and the offspring of the fourth successive consanguineous marriage consisted of six children all perfectly healthy save one, who is defective mentally—a defect, however, ascribable to an accidental traumatic injury. The founder of the race himself married a kinswoman, and among the descendants seven others have married cousins. Indeed, of the sixty-eight unions that have occurred, all feeling more or less the influence of consanguinity, but one has been infertile, and that infertility was due to disease of the mother, who was an alien; on the husband's side, moreover, it was necessary to ascend three generations to reach the first union of cousins. Among the two hundred individuals of this remarkably inbred family, all are very healthy, except the children of one of the latest marriages, in some of whom a tuberculous taint has appeared.

M. Voisin collected some observations bearing strongly on the favorable side of consanguineous marriages. In the commune of Batz, in Brittany, was a population of 3,300 souls, quite isolated from the rest of the department. In 1864, M. Voisin found in that community 5 marriages between cousins-german, 31 between cousins of the next degree below, and 10 between cousins of the degree after that. The first class produced 23 children free from all constitutional disease, 2 only having died of casual disorders. The 31 marriages of second cousins produced 120 children, all free of constitutional taint, 24 dying of acute disorders. The 10 marriages of third cousins gave 29 healthy children, of whom 3 died of accidental diseases. Sterility occurred in only two families, the parents being related to each other in the third degree (canonical). Mental disorders, idiocy, deaf-mutism, and hemeralopia were all unknown. The general health of the population was good.

The same author states, as the result of a careful examination of 1,077 of his patients at the Bicêtre and Salpêtrière hospitals, that in no one instance of his idiotic, epileptic, or insane patients could healthy consanguinity be legitimately regarded as the cause of the affection.

M. Seguin gives the result (*Comptes Rendus*, vol. lvii., 1863, p. 253) of ten consanguineous marriages occurring in his own family. One marriage was barren, but the average children in each of the ten marriages was over six. There was not a single case of deaf-mutism, hydrocephalus, impediment of speech, or supernumerary digits among all the children.

One great difficulty has been, in considering the returns of defective children born from consanguineous marriages, that we have no means of knowing what the proportion of consanguineous marriages themselves is. Until this latter element is learned we cannot tell whether the defective children of relatives are or are not numerous out of proportion to the children of the non-related. It is very desirable, therefore, that by some authority, like that of the census, the number of consanguineous marriages be ascertained. This, unfortunately, has never been done. A formal request to this effect was made by a scientific body of the director of the Eleventh United States Census, but was denied.

Mr. George H. Darwin, however, collected some valuable and novel observations upon this point (*Journal of the Statistical Society of London*, July, 1875; also, *Fortnightly Review*, July, 1875).

This writer, by means of ingenious computations which space is insufficient to allow of giving in detail, concludes that in London, comprising all classes, the first-cousin marriages are about 1½ per cent. of all marriages; in the urban districts, 2 per cent.; in the rural districts, 2¼ per cent.; in the middle and upper middle class, or in the landed gentry, 3½ per cent.; and in the aristocracy, probably 4½ per cent.

Mr. Darwin then collected returns from a number of lunatic and idiot asylums regarding the proportion of the inmates who were the offspring of consanguineous marriages, and found that where the figures obtained were most reliable, the proportion exceeded but slightly, if at all, the ratio of first-cousin marriages in the country at large, being from three to four per cent. Among deaf-mutes, also, the offspring of first-cousin marriages was almost exactly the same as the proportion of such marriages for the town and country.

Regarding the fertility of first-cousin marriages and of the descendants of such marriages, against which Professor Mantegazza, M. Boudin, and others have pronounced, Mr. Darwin finds, from figures obtained from "Burke's Landed Gentry" and the "Peerage," that the fertility, as shown by the number of sons surviving infancy, is somewhat greater in marriages of first cousins, and where one of the parents was the child of a first-cousin marriage, than when the parents were not consanguineous, the average number of sons in each of these three classes being respectively 1.92 to 2.07, 1.93, and 1.91. As to the youthful death rate, the evidence, from the small number of families (37) for which these data existed (all from the peerage), gave a slightly increased death rate in early years for the children of consanguineous parents.

While admitting a certain amount of truth in the popular sentiment in regard to the evil effects upon offspring of marriages of kin, Mr. Darwin holds that the evil has been much exaggerated.

The writer of the present article collected a series of cases of consanguineous marriages, whose results were embodied in a paper read before the Massachusetts Medical Society, June, 1885, and published in its "Proceedings" for that year. In 108 such unions 103 were fertile, producing 413 children. Excluding from the category of the "healthy" all who had any physical defect, including even polydactylism and strabismus, all who were below the average in mental or bodily vigor, all who developed phthisis or any other constitutional taint, even though it did not appear till late in life, and all who died in infancy, except when the death was known to be from some acute malady, 312 of the children, being 75½ per cent. of the whole number, were classed as healthy. The principal diseases and defects comprised 12 cases of deaf-mutism (all occurring in a small isolated community on the island of Martha's Vineyard), 7 of insanity, 13 of idiocy, and 15 of consumption. The fertility of all of the unions which were known to have lasted twenty-five years or over, 57 in number, was on an average 5 children to each couple.

There were 17 consecutive consanguineous marriages, *i.e.* those in which one or both the parties marrying in kinship were themselves descended from a similar union. Of these marriages only 9 had lasted the whole child-bearing period, and these produced 50 children. In all, from the 17 marriages, 15 being fertile, 68 children were born, of whom 48 were "healthy."

There were also 128 marriages not consanguineous, but in which one or both of the parties were descended from persons related. Some of the marriages had lasted but a short time; but 110, or 86 per cent., had already proved fertile, with at least 372 children, and probably many more. Only 47 of the unions were known to have lasted twenty-five years or over, and these produced 240 children.

An analogy of considerable significance to the question of consanguineous unions in the human subject is to be drawn from the so-called in-and-in breeding of animals. Bakewell, the brothers Collings, and Bates, in England, were the first to advocate and practise incestuous breeding among cattle. The Leicester breed of sheep and a breed of long-horned cattle were created by Bakewell on this plan, and with a good measure of success. The "Duchess" short-horned cattle, produced by Bates in the same manner, were also famous for a time, but have now become nearly extinct. Cattle breeders at the present time are divided in opinion as to the advantages of thorough in-and-in breeding, some claiming that this method in time will impair the fertility of the stock, and pointing for proof of this to the numerical deterioration of some of the breeds first formed on this plan. Their opponents say, on the other hand, that as long as Bakewell himself lived to give the benefit of his judgment to the selection of the individuals to be bred from, the stock retained its excellence. Moreover, there are numerous examples to be adduced in which incestuous breeding has succeeded in not only developing, but perpetuating a breed for long periods. M. Beaudouin tells (*Comptes Rendus*, August 5, 1862) of having inbred merino sheep very closely for twenty-two years without in any degree diminishing their fertility. The "Jersey" cattle have for one hundred and fifty years been bred on a small island only six miles by eleven (no larger than a western ranch), with no intermixture of foreign blood; yet, when first known to the outside world they were already an established breed, noted not only for their excellence as butter-makers, but for their beauty, docility, and intelligence. The early importations of these cattle to this country were, of necessity, very closely inbred. Indeed, some of the most striking instances of in-and-in breeding on record are among Jersey cattle. Take, for instance, the St. Helier strain. This bull was put successively to his daughter and granddaughter, and by the latter begot a son (Oxoli), which was also a great-grandson, and a daughter (Chromatella), which was also his great-granddaughter. Each of these animals had 87½ per cent. of the blood of their great-grandsire (seventy-five per cent. more than has a child by a nonsanguineous union). Chromatella was bred to the son of her brother Oxoli, and dropped two daughters, both healthy and good breeders. Oxoli also bred to three daughters of St. Helier (having fifty per cent. of the latter's blood), one of them being his own (Oxoli's) granddam. He also bred to several cows having seventy-five per cent. of the blood of St. Helier, of which he himself had 87½ per cent. In fact, the history of this strain shows a large number of unions of the very closest possible nature, a great majority of the descendants having more than fifty per cent. of the blood of their progenitor. Yet for excellence not only of the butter record, but of general health, and for fertility, the strain is most remarkable. Again, the bull Favorite, himself highly inbred, was put successively to his daughter, daughter's daughter, and daughter's daughter's daughter, he being the sire in each case. The result of this last union was a cow having 93¾ per cent. of the blood of Favorite, and the mother of some of the most remarkable animals known.

Among racing horses "Rysdyk's Hambletonian" may be mentioned as an example of a closely inbred horse. Yet it is stated on good authority that during the year 1883, among 190 new performers that entered the list of 2.30 trotters, 41 per cent. were by Rysdyk's Hambletonian, his sons and grandsons; while 20 per cent. of the residue were more or less closely related to Hambletonian.

It is important to bear in mind that what is called "in-and-in breeding" among cattle breeders, means a closeness of mating which is not only out of the question in the human subject on ethical considerations, but is far beyond the bounds of physical possibility. In mankind, a marriage between first cousins would give offspring but twenty-five per cent. of the blood of the common ancestor of the parents. The child of parents who are uncle and niece will have thirty-seven per cent. of the blood of the common ancestor; and even the product of the union of brother and sister will have but fifty per cent. of the blood of one of its grandparents. In other words, unions equivalent in closeness to the nearest consanguineous marriages made among men are not considered by cattle-breeders worthy the name "in-and-in" at all. Mr. Campbell Brown, speaking (as a disbeliever in incestuous breeding) of a horse that had been claimed as closely inbred, says "that he had only twenty-five per cent. of the blood of a certain other stallion," and adds "that that is a degree of inbreeding to which there can hardly be rational objection." Yet this is just the per cent. which the child of first cousins has in the blood of their common ancestor.

In comparisons between the results of in-breeding in animals and in man, we are to remember of course that in the former case there is a studied selection of the qualities in the individuals to be mated, while in the union of human beings affection is usually the only guide.

In estimating, however, the effect of consanguinity pure and simple as an element in the determination of offspring, it is proper to take it where it is free from all possible complication by inherited morbid influences. If cattle breeders, in their endeavors to perpetuate a fine breed by the principles of natural selection, can win success out of in-breeding, it follows that there is nothing in the fact of consanguinity itself in parents which of necessity deteriorates the offspring. When, therefore, it is objected that human consanguineous

marriages should not be compared to in-and-in breeding among animals, for the reason that in the former the principles of natural selection are not observed as they are in the latter, it may be answered that what is the same in the two classes of animals is unions of kindred, and that it is those similar conditions only which it is sought to compare. It is not denied, that "like produces like," whether of bad or of good and if a union of two imperfect individuals of allied blood produces diseased or defective offspring, it is in obedience to a law of nature too universal to be affected in any way by the accident of consanguinity.

The objection has also been made that the product of in-and-in breeding is not a perfect animal, but is, as Dr. Mitchell has expressed it, "a saleable defect," a "perfect pathological specimen," less useful to himself if he were to be left to himself and deprived of artificial care and keeping than the natural animal would be under like circumstances. Here again the influence of consanguinity has been confounded with that of natural selection. In accordance with the latter principle, any quality may be selected as the aim of breeding—as speed or strength in the horse; milk, draught, or flesh in cattle; wool or fat in sheep, etc. According to the point of view of the observer will the product of such breeding be intrinsically beautiful and valuable, or the reverse. A breed of pigs may be produced so fat that they cannot stand, and certainly "less useful to themselves" than in a natural state. Yet we have it on the best authority that no horse bears fatigue so well, or recovers from its effects so soon, as the thoroughbred. "Indeed," says an eminent hunting authority, "there is scarcely a limit to the work of fullbred hunters of good form, constitution, and temper." The argument that the thoroughbred animal is less "useful to himself," because he has become dependent on artificial conditions of food and shelter, would prove equally well that civilized man is inferior to the aborigines.

Deaf-mutism is a defect which has been said to bear a special relation to marriages of near kin. This general impression is doubtless due to the undeniable frequency of deafness among the children of unions where one and especially where both of the parties are deaf. This liability is greatly enhanced if the deafness of the parents is congenital, or if either of them has deaf relatives. On this ground Professor Bell has urgently advised that deaf-mutes, if they marry, should select hearing persons and those too, only, who have no deaf relatives. He says that a deaf person (not born deaf) who has no deaf relatives will not increase the liability to deaf offspring by marrying a blood relation; but a congenital deaf-mute under the same conditions he thinks will. While a deaf person, so born or not, who has deaf relations will especially increase this liability in the offspring if he marries a relative on the same side of his family in which other cases of deafness have occurred.

Boudin asserted that deaf-mutism was specially selected by Providence as the punishment for the violation of "nature's law" involved in consanguineous marriages, in order that man, as the "talking animal," may bear the brunt of penalty. But Dr. Child has shown that deaf-mutism is simply a congenital deafness to which mutism has succeeded because the individual cannot hear himself speak, and that the same defect, congenital deafness, may and does exist in the lower animals. Indeed, the whole drift of modern science is against such attempted distinctions. Man is physiologically an animal, and in the manner of his propagation is subject to the same laws as any other animal. If, then, as seems to be the case, analogies drawn from the lower animals show that even "in-and-in breeding," in the hands of practical men working for pecuniary returns, gives good results in the form, usefulness, and fertility of their stock, it is a fair inference that at least the occasional admixture of a comparatively small amount of kindred blood, involved for instance in a marriage of cousins, is innocuous in the human species.

How, then, shall we reconcile the above conclusions with figures such as those published by Bemiss, Howe, Mitchell, and Boudin? Have no unfortunate results been found from consanguineous unions? Undoubtedly; but such results have followed for the most part, and probably exclusively, where consanguineous marriages have intensified morbid characteristics of both parents. One must not attribute to consanguinity what belongs properly to heredity, though, if consanguineous parents have a common defect, it is obvious that in such a case consanguinity may readily become a factor in promoting an undeniable inheritance. As Le Gendre has said, consanguinity exalts hereditary defects but does not create them. On the other hand if the consanguineous parents are thoroughly healthy, their children may have an unusually good chance of being vigorous and efficient. Children have a tendency to revert to a common ancestor. If the common ancestor of both parents is not a remote one (by reason of their consanguinity), the type to which the child reverts is not the common type of the race, but is that of this comparatively recent ancestor, say, a grandfather. Should that ancestor possess exceptionally desirable qualities, the child stands a chance to be above the average of its fellows. But if this common progenitor has a depraved or diseased quality of mind or body, it is more likely to find expression in the child inheriting from him in two lines, than in that inheriting from him only in one. Because any newly acquired taint in an individual is much less likely to lose itself in his descendants if diluted in an extraneous strain than if intensified by being multiplied into itself, and so going on in a sort of geometrical increase.

It must be admitted that many families do possess physical and mental traits whose perpetuation would be undesirable. And it is this fact which lends whatever danger there is to consanguineous marriages. It is perfectly true that what has been called "social consanguinity" in marriage is open to much the same objections as true consanguinity. If marriages are constantly contracted within the same locality and social environment, the resultant offspring may become as eccentric mentally and feeble physically. Probably relations living under the same roof should be more carefully examined for common defects and peculiarities before sanctioning their marriage, than if the same individuals had lived in different localities. Certain royal families have suffered perhaps as much from the lack of this social dilution as from anything else short of the actual in-breeding of disease.

To conclude, a danger exists to the offspring of related parents if these parents are sharers in any family disease or tendency thereto, and not otherwise. Consanguineous marriages (in-breeding) fix the characteristics, good and bad forms, races, and species. If safeguarded as above indicated, they are capable of ensuring an unusual mental and physical excellence in the resulting progeny. Some of the greatest geniuses have doubtless been so produced. Exogamgeniuses have doubtless been so produced. Exogamous marriages on the other hand (cross-breeding) within the limits of a given race, not between two different races tend to rejuvenate and vitalize the stock.

CHARLES F. WITHINGTON

**Consciousness, Disorders of.**—Putting aside all subtle metaphysical or abstract psychological distinctions we shall arbitrarily conceive of consciousness as those directing cerebral mechanisms which handle life's energy for the production of useful work, the word useful being used in an extremely broad sense. Just how consciousness grew out of tropisms, what its subtle distinctions may be from reflexes, what are its relations to the unconscious, these are matters which for the present lie outside of this discussion. It is

assumed that consciousness is a higher evolutionary product, assuming greater and greater control and precision as the opportunities and needs for adaptation to reality seem to grow in the advancing animal scale. That consciousness may still be made a better and better instrument for adaptation to reality goes without saying.

Adaptation to reality is a complex function of the cerebral mechanism and we may follow Bergson in saying that it is through both instinct and intelligence that this takes place. In intelligent or logical activities consciousness is assumed. Is there a consciousness in instinct? This question brings one back to the matter of tropisms, of reflexes, and of the unconscious. To present this latter problem Bergson assumes two kinds of unconsciousness, one in which consciousness is an absent factor and one in which consciousness is merely nullified. As he says both are equal to zero, but in one case zero expresses the fact there is nothing, in the other that there are two equal quantities of opposite sign which compensate and neutralize each other. Thus one may speak of the unconsciousness of a falling stone. Instinct however has a different type of unconsciousness. When one performs an habitual action, when a somnambulist automatically acts out a drama, as did Lady Macbeth, unconsciousness may be absolute and yet of what does it consist. Bergson holds with reason that the representation of the act itself resembles the idea so perfectly, and fits it so exactly, that consciousness is unable to find room between them. Freud, Jung, and Bleuler would speak of this as a special kind of thinking in which consciousness is suppressed into unconsciousness by reason of the effect. Phantasy thinking or autistic thinking results. The dramatization is the action and as Bergson shrewdly notices the representation is stopped by the action. As proof this latter author calls to mind the fact that if the accomplishment of the act is arrested or thwarted by an obstacle, consciousness may reappear. It was there but neutralized by the action which fulfilled, thereby filled the representation. This inadequacy of act to representation is what Bergson calls consciousness. He is worth quoting further on this point since much of the knowledge of psychopathology gained by psychoanalysis tends to confirm a part of his attitude. If we examine this point more closely, we shall find that consciousness is the light that plays around the zone of possible actions or potential activity which surrounds the action really performed by the living being. It signifies hesitation or choice. Where many equally possible actions are indicated without there being any real action (as in a deliberation that has not come to an end), consciousness is intense. Where the action performed is the only action possible (as in activity of the somnambulistic or more general automatic kind), consciousness is reduced to nothing. Representation and knowledge exist none the less in the case if we find a whole series of systematized movements the last of which is already prefigured in the first, and if, besides, consciousness can flash out of them at the shock of an obstacle. From this point of view, the consciousness of a living being may be defined as an arithmetical difference between potential and real activity. It measures the interval between representation and action.

It may be inferred from this that intelligence is likely to point toward consciousness, and instinct toward unconsciousness. For, where the implement to be used is organized by nature, the material furnished by nature, and the result to be obtained willed by nature, there is little left to choice, the consciousness inherent in the representation is therefore counterbalanced, whenever it tends to disengage itself, by the performance of the act, identical with the representation, which forms its counterweight. Where consciousness appears, it does not so much light up the instinct itself as the thwartings to which instinct is subject; it is the deficit of instinct, the distance between the act and the idea that becomes consciousness, so that consciousness, here, is only an accident. Essentially, consciousness emphasizes only the starting point of instinct, the point at which the whole series of automatic movements is released. Deficit, on the contrary, is the normal state of intelligence. Laboring under difficulties is its very essence. Its original function being to construct unorganized instruments, it must, in spite of numberless difficulties, choose for this work the place and the time, the form and the matter. And it can never satisfy itself entirely, because every new satisfaction creates new needs. In short, while instinct and intelligence both involve knowledge, this knowledge is rather *acted* and unconscious in the case of instinct, *thought* and conscious in the case of intelligence.

Before discussing this subject further a glance at the organs in which these mechanisms are concentrated may aid in fashioning a workable concept.

*Cerebral Localization.*—The general biological principle of the concentration of energy as a feature of advanced evolutionary development finds its expression for the psychical sphere in the more or less distinct localization of definite functions to certain portions of the brain.

For the purely vegetative activities such localization is fairly definite, and we know that the areas governing the various members are accurately located. The important sense organs also show a like integration, and the localization of so-called centers for sight, hearing, smell, and motor speech now admits of little question.

It is, by more or less common consent, based on general grounds, as well as on the data afforded by physiological experiment and pathological observation, as well as by the study of the comparative psychology of the lower animals (by Romanes, Darwin, Morgan, Mills, and Thorndike), that the higher mental processes (*i.e.* those that are more complex and those which have developed late in the evolution of the race) utilize the frontal lobes of the brain in their activities; but it is certain that, so far as the ego is concerned, taken in its totality, no such localization can exist. The whole brain is the psychical organ, and the sense of the ego depends on such a multitude of sensory impressions that its location is coexistent with the nervous system in its totality. It is to be borne in mind that the complex nexus of associational fibers should be considered constant factors in the idea of a consciousness. The great modifications that occur in consciousness—due to the cutting out of action of certain of such associated fibers—is a constant feature in certain hemiplegic states, and probably some similar pathological entities lie at the foundation of some of the modifications of consciousness in some of the psychoses, notably general paresis.

Within recent years the labors of the histopathologists have brought into prominence the importance of minute structural changes of the connections of the various nerve processes; collaterals, axis cylinders, and dendrites, forming plexuses of communication between various systems of nerve-cell groups. Such changes are closely correlated and are the probable direct causative agents of many of the symptoms of mental disease, such as loss of attention, diminished initiative, amnesia, blunting of the higher ethical ideas, insomnia, and many of those psychical activities which modify conduct so largely, and hence are representative of the empirical ego. As put by Mills, from Andriezen: "The earliest changes in many if not most of the psychoses are in the cortical fields of conjunction, the regions in which anatomical units or groups of them are brought together. These fields of conjunction become less and less permeable to all forms of excitation, and one of the first results is 'delay in reaction time.' The association system, which gives way first in these cases, is probably represented most in the polymorphic

layer of the cortex; it is the last and the least organized, although subserving the highest functions, especially volition, and in chronic processes of disintegration it is the first to go."

From such a purely preliminary sketch it can be seen that it is futile to attempt to speak of a localization of consciousness as if such a faculty were a thing *per se* rather than an attribute of psychical nerve activities.

Connected, however, with this question there are to be considered certain localizations of some of the more clearly defined psychical activities.

Evidence derived from the lower animals points to the fact that following the ablation of the prefrontal lobes there is more or less mental degradation. Close attention is lost, and observation which looks for the safety of the animal is often notably affected. Attention, judgment, memory, and notably inhibition are factors of the ego which are notably modified by disease or injury to the frontal lobes, and with such are associated hesitation, fear, uncertainty, and motor restlessness due to impaired inhibition.

Studies of anencephalous monsters have shown that without a cortex, but yet possessing enough of the cerebrospinal mechanisms to bring spino-thalamo-bulbar fibers into play, many automatic activities may take place, notably sucking. Goltz's celebrated decerebrate dogs and the later studies of Rothmann also have shown that highly complex reflex activities may be carried out by these pallium-minus dogs. Hence one may say that certain instinctive activities persist but no intelligent ones. In these instinctive activities there is that type of unconsciousness already spoken of as represented by the absence of consciousness. The thwartings to which the instinct is exposed in this case cannot give rise to consciousness.

What are Disorders of Consciousness? From the unconsciousness of death and that of accident, and the profound intoxications, to sleep; through the mild grades of unconsciousness in many of the sleep phenomena, somnambulism, the hypnotic state, and its allies; through normal waking consciousness; through the active exalted states of dramatic abandon, ecstacy, the minor intoxications, to the distinctly diseased emotional states of hysteria and epilepsy and the psychoses, finally to the living death of dementia, there is the gamut of the human psychical activities divided into a few cardinal categories which admit of general classification.

Just what shall constitute a normal state and what an abnormal state must be left largely to the study of majorities. Conduct is the great criterion of consciousness, and for most practical purposes it may be assumed that disordered consciousness is correlative with disordered conduct.

In discussing the subject of disordered consciousness it has been the custom to describe three types: exalted, diminished, and perverted states. While this classification is extremely convenient for many purposes, it fails to give an idea of the clinical significance of any particular phase. It is only too frequently the case that the same clinical groups, hysteria or epilepsy, for example, will demonstrate all these separate states, which at times merge within each other or follow one another with bewildering rapidity.

The more important question seems to be: Given a definite mental state, which, judged from conduct, departs so far from what a broad experience teaches to be a fairly normal state, to what factor or factors is such an abnormal state due, into what category does it fit, and how can it best be regulated or controlled to insure the best results to the individual and to society?

The subject of categories of the clinical groupings of such disordered conscious states will be here only touched upon. Such a problem in classification is manifestly extremely difficult because of the extreme richness of the emotional content of consciousness, and the few rather broad categories here proposed are to be regarded purely in the light of general convenience rather than as attempts to cover the entire ground.

The disorders of consciousness for the present purposes are broadly divided into a few general groups. These are: (1) Disorders of sleep and the allied phenomena; (2) disorders of the neuroses and psychoneuroses, including the phenomena of automatism, double consciousness, amnesia, etc.; (3) the intoxications; and (4) the psychoses. Such a classification is manifestly incomplete and imperfect. Thus many of the phenomena of groups (1) and (2) are interchangeable. It is moreover popular at the present time to attribute most of the psychical ills to various toxemias, either autogenous or heterogenous, and it is certain that no hard-and-fast line can be drawn clinically between certain maniacal states due to intoxication and those of a purely psychical etiology. In the present unsettled conditions of neural pathology, to say nothing of psychological classification, the question of categories may be an academic one after all.

1. Disorders of Sleep and Allied Phenomena.—(Dreams, Somnambulism, Trance, Lethargy, Catalepsy, Hypnotism, etc.) Under this category there are included a large number of closely allied phenomena, the most striking feature of which is a state originally termed by Janet dissociation of consciousness. In most of these phenomena the ordinary waking conscious state, with its refinements of judgment, inhibition, etc., is in temporary abeyance, naturally or artificially induced, and the patient dramatizes his unconscious phantasies. The meaning of these dramatizations may be evident or they may suffer from a number of psychical modifications, such as conversions, distortions, displacements, condensations, etc. (see article on *Dreams*), which mechanisms make it difficult or impossible to understand the meaning of the whole phantasy. (See Hitschmann, Freud's Theories of the Neuroses, Nervous and Mental Disease, Monograph Series, No. 17.)

*Somnambulism.*—The simplest type of such phantasies is found in some somnambulistic states. In these the individual may perform, while still asleep, many of the simpler acts of the waking state, and indeed even many extremely complex acts are carried to completion. The patient awakes without any conscious recollection of the acts performed, and often such acts have been harmful to self and society.

The clinical phenomena are not constant. The eyes are frequently closed or semi-closed, or even wide open and staring. The pupils are apt to be sluggish in their reactions, but may be normal in diameter, dilated or contracted. The data collected by Gould and Pyle ("Anomalies and Curiosities of Medicine") may be referred to by those who would learn more of the complicated motor acts that many notable cases have been known to perform. Suicide and homicide have been committed by persons in the somnambulistic state. The somnambulistic state is recognized to be a special instance of autistic or phantasy thinking. The patient acts his unconscious phantasy, often with evident, but more often with complex and veiled symbolisms. Association experiments and psychoanalysis seem to prove that the experiences lived during the somnambulistic state may be brought to consciousness. Some register is made in consciousness since a memory of them may be awakened. This does not mean that the individuals have a knowledge of what they were doing at the time it was done. This commonplace of medical science is one of the stumbling blocks of law, where the ignorance of lawyers has given rise to the stupid and unjust definition of "responsibility." Somnambulistic performances carry out the general trend of the unconscious, i.e. toward fulfillment of instinctive desires.

*Nightmare.*—This is a painful dream state. In many instances, where such are extremely distressing,

they have been known to precede grave cerebral disturbance, but it is not certain that they have any close relationship with the same, save perhaps in certain types where the fear of death appears in symbolic form. As they influence conduct but little, they are to be regarded as disordered states only in certain severe cases. The more recent studies of Freud, Jones, and others have pointed the way to a better hypothesis of these nightmares. They are discussed more fully in the article on *Dreams*.

*Lethargy, Catalepsy, Trance.*—These are terms used to describe atypical unconscious states which are as yet imperfectly classified, partly on account of the fugitive character of the alterations and partly because of the complications of the picture with other symptoms of the hysterical and epileptic conditions. The phenomenon of hypnotic sleep is best put in this category.

In catalepsy the prevailing phenomenon consists of the wax-like rigidity which the limbs can be made to assume, at times unconsciously; again, especially in the hypnotic condition, by the suggestion of the operator. In trance conditions there may be manifest a great variation of phases, most of which are accompaniments of the hysterical state. All of these phenomena which occur in a variety of the psychoneuroses as well as in the psychoses, cataleptic states, lethargies, trances, etc., being extremely frequent in hysteria and more particularly in catatonic types of schizophrenia (dementia præcox), have been much better understood, thanks to Freud's ingenious hypotheses. They all represent, as stated, wish-fulfilling phantasy dramatizations, the precise significance of which can be laid bare by the principles of psychoanalysis.

2. Disordered Conscious States in the Neuroses and Psychoneuroses.—No sharp dividing line separates the neuroses from the psychoneuroses so far as the prevailing disturbances of consciousness are concerned. Here under the neuroses are considered neurasthenia and anxiety neuroses, while hysteria and the compulsion neuroses (morbid phobias, fears, compulsion ceremonials, etc.) are here termed psychoneuroses. For neurasthenia, the chief phenomena are fatigue states, anxiety states in the anxiety neuroses, conversions of psychical unconscious states into physical phenomena (blindness for not willing to see, deafness for not desiring to hear, paralysis from phantasies of various kinds, etc.); indeed the whole gamut of somatic signs of hysteria may be mentally reviewed by the reader as falling under the formula conversion. Finally in the compulsion neuroses there is an erection of psychical defenses which show the phenomena of substitution. Here the sources of the emotion in unconsciousness are transferred or displaced to some irrelevant matter which comes to symbolize in some manner the nature of the unconscious, suppressed emotional situation.

In many *neurasthenic states* organic factors loom large in determining the feelings of fatigue in consciousness. Others again, however, are purely emotional in their development and here conscious and unconscious processes are in rivalry. The desire to be sick to escape obligation; the reversion to indolence unconsciously is a large motive. The libido, that is the energy of these individuals, concerns itself with their own bodies and they live, in phantasy, as neurasthenics, the life of the cared-for and nursed child. Here unconscious phantasy helps to disguise the task —that is to be independent captains of their own destinies.

In the *anxiety neuroses*, physical states are also present, such as flutterings, tremblings, gaspings for breath, air hunger, very frequently palpitation, fear of impending death, anxiety lest something may happen to self, to others, or to material welfare, diarrheas, mucous colitis, gastric irregularities of all types, etc., etc., etc. These make up the physical signs induced by the unconscious phantasy, largely of temptation. These patients are constantly repressed; they suffer from suppressed excitement and the symptoms mentioned constitute the outlet for the repression, the exact nature of which is veiled behind the symptom, not as a true conversion as in the hysterical mechanism, save in certain mixed anxiety hysterias. Freud and Stekel as well as many others assume that this type of disorder is found more particularly in those who find the demands of culture too arduous, and yet whose ethical attitude refuses to face a certain, often but not invariably a sexual, situation. Unrequited affection, dissatisfaction with life's sternness, actual sexual stimulation without gratification—as in coitus interruptus, coitus reservatus, menopause, artificial and natural—unconscious temptations toward dishonesty, hateful impulses repressed from consciousness—these are among the dynamic factors bringing about these peculiar modifications of conduct to meet these situations.

In *hysterical conversions* the mechanisms are more complex. Here the complexes play a more determining rôle and the cast-off and yet still retained complex is more precise and definite.

Thus the essential factor, so far as consciousness is concerned, is dissociation which, according to the original view as held by Janet, is due to an inborn weakness, namely, some factor in the constitution of the individual which predisposed him to this type of reaction. Hence, by the French school, and by those who followed Janet's teachings, the search for this inborn factor was made chiefly in the prenatal life of the individual, namely in heredity, and unfortunately as a correlate of such teachings a pessimistic attitude toward therapy was inevitable The chief advance made in the hypothesis formulated by Freud was that the factor bringing about dissociation was not so much to be sought in heredity as to be looked for in the psychological dynamics of the nervous system, so that, for reasons which psychoanalysis has revealed, a certain group of ideas or complexes remained in the unconscious, but were still active. Hence arose the concept of repression as worked out by Freud.

Inasmuch, however, as the dynamics of the nervous system could not be interfered with, some form of expression of energy must take place. The repression acting upon this discharge of energy brings about the process of conversion, that is, there is a motor discharge but the repression distorts it—puts a different face upon it, so that the patient carries out the unconscious repressed wish in a form of dramatization known as the symptoms of the disease.

This dramatization, concerning which a much more extended discussion will be found in the article on *Hysteria*, presents a number of distorted mechanisms which a study of the dream life has made clear. These distorting mechanisms permit the living out of the wish, at the same time that it remains practically unconscious. Mixtures of conscious and unconscious phantasy are present in practically all hysterical attacks, so that they present various combinations.

The symbolism of the attack itself may represent a number of things. Thus, among the commoner forms of dramatization one finds that:

1. The hysterical symptom is the memory symbol of certain actual traumatic impressions and experiences.

2. The hysterical symptom is a substitute created by conversion for the associative returns of these traumatic experiences.

3. The hysterical symptom is like other psychic formations, the expression of a wish fulfilment.

4. The hysterical symptom is the realization of an unconscious phantasy, which serves a wish fulfilment.

5. The hysterical symptom serves to represent a sexual gratification, and represents a part of the sexual life of the patient.

6. The hysterical symptom corresponds to a return to a kind of sexual gratification which was real in infantile life, but which has since been repressed.

7. The hysterical symptom arises from a compromise between two opposed affective and instinctive impulses by which the one brings a partial instinct or component of the sexual repression to expression, the other seeks to suppress the same.

8. The hysterical symptom can become the representation of different unconscious non-sexual impulses, which cannot, however, be without a sexual meaning.

9. An hysterical symptom is the expression on the one hand of a masculine, on the other of a feminine unconscious sexual phantasy.

These represent the more easily recognized interpretative formulæ of an hysterical attack, number 7 being the most frequent.

The chief interest, however, in interpreting this pantomime resides in the close similarity which it presents to the pantomimes of dreams and myths, and of fairy tales. We thus see that the misleading, incomprehensive, and indistinct outlines of the attack consist:

1. In a combination of several simultaneous phantasies, for example, a recent wish and a revival of an infantile repression.

2. In a multiple identification when the patient undertakes to carry out the activities of both persons appearing in the phantasy.

3. In the antagonistic conversion of motor innervation so that a negativistic expression is to be interpreted in the light of its opposite.

4. In an inversion of the time sequences; this complicates the picture, just as an inversion in the motor character of the phenomenon and an hysterical attack may begin backward and work forward, just as a cinematograph film may be displayed running backward.

In hysterical dream states the unconscious activities may be readily understood by one who is capable of understanding the pantomime. The patient plays the part with unerring accuracy.

*Compulsion Neuroses.*—Here the unconscious factors are handled in a manner somewhat different from that seen in hysteria. Under this head is usually included a large number of obsessive, phobic, and compulsive ideas which represent an unsuccessful repression of the psychosexual conflict. Unlike hysteria, the conflict is apt to come into consciousness; it cannot be entirely disguised by the distorting mechanisms. Conversion is not so frequent a phenomenon, but instead another type of reaction is met with, namely substitution. By this is meant that the repressed conflict, breaking into consciousness, does not come into consciousness in its true light, but is immediately transferred or transposed, that is substituted, upon something that is innocuous. A common illustration from every-day life illustrates in part this mechanism. Thus, an irritable husband with a burden to carry, immediately on sitting down to breakfast complains about the coffee; notwithstanding the fact that the coffee may be the same that he has been drinking for fifteen years, on this particular morning it is atrocious. Here the psychical disturbance, the discomfort, the irritability is transposed or substituted upon the innocuous object, and one that has nothing whatever to do with the original source of irritation, but serves as a carrier or outlet for it. Thus the phobia, the compulsive act, the obsession becomes the innocent object for the expression of the emotional or complex disturbance of the patient. Thus, a patient will be unable to look upon a negro, will refuse to go out of the house without securing the door a number of times, or may have to put white papers under the beds, or in dark closets, have to look at people two or three times to be persuaded that they are not negroes, and a complicated ceremonial grows up about the question. The negro is only a symbol and behind the [illegible] the original difficulty.

To understand the activities of the unconscious in the compulsion neuroses is very difficult, but perhaps the most illuminating hypothesis that has been utilized for the explanation of these phenomena is that of Freud. He assumes that the fairly developed neurosis, say of a person of from twenty-five to thirty-five, or even forty years of age, represents the terminal stage of a complicated series of phenomena. The initial stage is usually laid down in childhood where, as a reaction to infantile attitudes usually of a nature to satisfy sexual curiosity, then not known to be sexual; the patient comes to a sense of guilt concerning these activities. This sense of guilt is usually overcompensated for by little manifestations as it were of overgoodness. The children become very punctilious, very fond of their parents, intensely religious or intensely self-sacrificing, do everything they can to be good, which is hardly the normal state of childhood. They are compensating for something which needs to be compensated for apparently, and the compensation aids in pressing memories of the early experiences or phantasics into unconsciousness. It may be that this overcompensation is effective, as it frequently is in mystics, religious enthusiasts, zealots, reformers, extremists, and cranks of various kinds, but not infrequently the overcompensation breaks down, the original phantasies which have been put to sleep reawaken now with a much stronger imperativeness, and immediately a conflict arises, whereby the demands of the original instincts of gratification can be accomplished, and also whereby the demands of a cultural attitude may be maintained. A ceremonial which represents these conflicting tendencies develops whereby the patient can keep his cake and eat it too. The mask that is worn is of various types, as any one who has had a large experience with compulsion neuroses can testify. Sometimes an overdetermined symbolism may in the course of time become extremely complicated. The patient is driven from one level to another, and in the search for rest lights upon a series of islands of safety as it were, to be swept away and have to search for a new one. Thus successive lines of defenses grow up, and in every old compulsion neurosis the unravelling of the various lines of defense becomes an extremely difficult matter. It is highly probable that no compulsion neurosis can be analyzed within six or eight months, and some cases take one or two years. They constitute the hardest problems in the treatment of the psychoneuroses.

Intoxications.—An adequate discussion of the disturbances of consciousness in the intoxications would require a large volume. Those resulting from the action of alcohol alone would require a monograph. The study of the influence of alcohol upon consciousness is one of intense interest, since in increasing dosage one can observe, along the retrograde path, the whole phylogenetic and ontogenetic development of consciousness. In comparatively small doses the conscious development of higher culture may be peeled off, then those of less advanced grades disappear; an individual man may in successive layers be shown through all of his psychical stages of development. At the vital level he represents the spinal animal, still feeling and living, but reflex orientation may be preserved. Consciousness is here reduced to unconsciousness and all of the prereactions of the anencephalous monster may be preserved. Finally passing below vital levels alcohol reduces the human animal to a physicochemical apparatus, in which the only functioning parts are the sympathetic metameres. Here unconsciousness is at its lowest level, if unconsciousness one wishes to call it, for here mere tropisms show themselves. The lungs continue their oxygen exchange, the kidneys their chemical filtration and all other organs of the body

carry out their physical chemical functions, but lacking all coordination, all interrelationship. Every cell is looking out for itself independently one of the other, anarchy and chaos rule, and only the vagus preserves its activity in respiration and in the heart beat. Here are bits of primordial protoplasm which started the evolutionary series. Everything that man is or ever has been may be reached by the alcohol path, and as is well known it chiefly is the "has beens" that are acquired.

Psychoses.—Here disturbances of consciousness are most varied. It is practically impossible in the present state of our knowledge to apply the scheme of our stages of evolution to them. Certain psychoses reduce the individual to the physicochemical level, such for instance as paresis, senile decay, even certain stages of dementia præcox drop to this level. The intoxication and infectious psychoses, those associated with disintegration and degeneration of brain tissues also show the same results. Other psychoses only bring man down to his vital levels, return him to the animistic stages of development, whereas others again only involve him in his higher psychical sphere. Here symbolism becomes affected, and although the patient may not come in conflict with his surroundings, nevertheless he is out of touch with certain types of reality. No consistent applications of the hypothesis can as yet be made to the psychoses without a much more extended discussion. This will be done in the articles on the various psychoses (which see).

Smith Ely Jelliffe.

**Constipation.**—This term is applied to an abnormal sluggishness in the movement through the intestinal canal of its contents. In extreme cases, when the bowel becomes entirely closed up, one speaks of the condition as obstipation. When there is a movement daily, but the amount is small, so that an accumulation takes place within the intestine, it is called costiveness. It is obvious that there is no sharp line separating constipation from health. But in general it may be said that most persons to be in health require to have a stool daily. Exceptions do occur; some people habitually have an operation only once in two days, and show no signs of suffering from the lack of daily evacuation; others habitually have more than one discharge a day. The dejection should be moderately soft in consistence, and cylindrical, not spherical, in form.

Among the symptoms, other than infrequency and incompleteness of defecation, may be mentioned headache, furred tongue, foul breath, muddy complexion and conjunctivæ, a sense of weight in the abdomen. The constipated condition may even be masked by a diarrhea affecting only the lower bowel, while an actual impaction exists above. At times, moreover, in the cecum and colon hard masses may accumulate in sacculi in the periphery, while a moderate amount of liquid feces flows along the center of the gut. Many of the symptoms of constipation are those of dyspepsia, the two conditions often coexisting, and mutually aggravating one another.

The causes of diminished bowel action are numerous. First may be mentioned mechanical or structural causes, including adhesions, bands resulting from inflammatory deposits, new growths within and without the intestine, constrictions, invaginations, twists, for whose discussion the reader is referred to their appropriate heads. The non-structural causes only will be considered in this article. Dilatation of the intestine with atony is, perhaps, the commonest cause of constipation. The fault lies especially in the large intestine, which is intended especially as a receptacle for the feces. Normally, they rest, in the intervals of defecation, in great part within the sigmoid colon, and the rectum is for the most part empty. The passage of a portion of the dejecta into the rectum and the vicinity of the sphincter sets up that irritation which by reflex action produces the phenomenon of defecation. If this call is habitually neglected, the sensibility of this portion of the bowel is blunted, so that a great accumulation of fecal matter may take place. This dilates the bowel and still further obtunds sensibility, so that a vicious circle is established and the evil is increased. Another cause of this condition of things is the lack of a regular habit of defecating at a fixed time daily. It seems possible to train the intestine, as it were, to send its contents into the rectum at a stated time daily; and if this periodicity can be secured, one has a powerful aid toward regular and complete evacuation. From the atony above described one finds various degrees up to paralysis of the peripheral nerve endings in the intestine, and of the centers in the cord presiding over peristalsis and defecation. Again, the atony may not be confined to the unstriped muscles of the intestine, but may affect the voluntary muscles as well. This is especially the case in obese persons, and those having lax, pendulous bellies, as after numerous pregnancies. Deficiency of secretion of the intestinal glands contributes to constipation by lessening the fluidity of the chyle. Overactive absorption of the fluids of the chyle may act in the same way; this occurs in febrile states, and when the perspiration is abundant. Anemia is usually given as one of the causes of constipation; perhaps it would be truer to say that the two conditions have some causes in common; among them an indoor life and sedentary occupations. Probably a large proportion of individuals engaged in sedentary callings suffer at some time from constipation. This is especially the case in those who have changed their mode of life from a more active one, as in the case of students who have formerly been active bodily workers. Any change in surroundings, even though it does not involve a lack of exercise, may cause constipation, as when a person removes from one climate and soil to another. The change of water very possibly adds to this effect. Most landsmen taking a sea voyage suffer more or less from constipation. Congestion of the mucous membrane of the bowel has sometimes a constipating effect, especially when it is due to chronic venous obstruction. For this reason diseases of the liver involving passive congestion of the portal system are often attended with constipation. The explanation seems to be that long-continued passive congestion leads to thickening of the mucous and submucous coats, which impairs peristalsis.

Some forms of cerebral disease, notably tuberculous meningitis, are attended with constipation to a greater degree than other maladies of like febrile intensity. An important aggravating, if not primary, cause of constipation is the use of cathartics. These are seldom if ever required in the treatment of constipation, laxatives always being preferable to purgatives. But, through a mistaken notion of what is needed, the laity are much addicted to the use of powerful cathartics, which, though they relieve temporarily, in the end aggravate the difficulty. Enormous quantities of cathartic pills, chiefly of the proprietary order, are consumed by the public, and no small proportion of their users arrive at that unfortunate condition when nothing but a repetition of these drastic purges will procure them an evacuation. Improper foods are another cause of constipation; among such we may mention those which are specially concentrated, so that they leave little residuum; a certain bulk of unassimilable residue is necessary for the intestine to act upon. Foods that are too bland, as milk, act in the same way, not affording an irritation sufficient to stimulate peristalsis. This effect of faulty foods is specially observable in young children. Finally, chronic lead-poisoning has among its symptoms marked constipation; here of course, ordinarily, one can obtain the collateral evidence of colic, blue line on the gums, etc.

Much of the importance attaching to constipation depends upon the effects which it produces. Among these that upon the digestive function has been referred to. It is perhaps to the latter that the mental depression so often observed in constipated persons is more directly due; but however this may be, the coexistence of constipation with mental irritability and melancholy is often marked. Intestinal catarrh may be induced by constipation, and may, as already hinted, show itself by a diarrhea actually coincident with constipation in other parts of the bowel. The catarrhal process occasionally localizes itself, notably about the ileocecal valve; inflammation here (typhlitis) may go on to ulceration, and even perforation, or may by extension cause perityphlitis, with or without ulcers. Other neighboring viscera may suffer from overloaded bowels; a distended and dilated rectum may cause uterine congestion, thence proliferation of tissue adds weight and finally causes displacement. More frequently is its aggravation of symptoms due to uterine disease that had an independent causation. Neuralgias, ovarian, and especially of the sciatic nerve, may be determined by constipation. In the male, seminal emissions are sometimes so caused. Hemorrhoids constitute one of the most annoying and serious consequences of constipation, the distention of the hemorrhoidal plexus being evidently aggravated by a loaded rectum. The general effects of the irritation of the blood by the absorption into it of the contents of the lower bowel, through the prolonged exposure of the latter to an absorbing surface, are shown by the fact that repair of traumatic injuries and operative wounds is observed to be delayed when the bowels remain for a long time constipated. From this it seems reasonable to suppose that other vital processes, depending upon a healthy state of the blood, are similarly hindered by habitual inaction of the bowels. Autointoxication has lately come to be recognized as a cause of many diseases, especially of a mental or nervous character.

Treatment.—This is often a matter requiring great judgment and patience. Some of the essentials of treatment have been hinted at in what was said of the causes of constipation. Special attention should be paid to the prevention of this trouble in young children, by training them from their earliest years to regular habits in this regard. The person who is suffering from constipation must be enjoined to select a definite hour (if possible, directly after breakfast), when he will be able daily to devote at least fifteen minutes to securing a proper evacuation. This attempt should be made daily, whether the desire is felt or not, and in time the endeavors will gradually become more and more successful. The water-closet should be made comfortable enough, so far as temperature and accessibility are concerned, so that the individual can spend that amount of time in it without danger of taking cold. Unsheltered and exposed privies are a fertile source of constipation in delicate women. After a stool occurs, a few minutes should be given to see if a further amount of fecal matter finds its way into the rectum, a thing which often happens. It should never be allowed to remain in the rectum, for that will blunt the sensibility of the mucous membrane, and so delay the cure. A call to defecate, no matter when it occurs, should never be neglected for a moment. The "postural" treatment has been recommended, wherein the patient assumes a squatting rather than a sitting attitude, thereby securing a mechanical advantage in the act of defecation. The diet is of great importance to a constipated subject. Fruit is usually of benefit, particularly figs, berries, stewed prunes, and baked apples. Agar-agar (Japanese isinglass) widely used as a culture medium for bacteria, has been used with success for chronic constipation with intestinal atony. It renders the feces soft and bulky and promotes peristalsis. It is usually administered in small strands mixed with fruit, milk, or any convenient vehicle. It is not attacked by the digestive secretions and passes almost unchanged into the intestinal canal. Oatmeal has a popular reputation in this regard, though occasionally persons are found upon whom it seems to have a binding effect. Brown bread and molasses are anticonstipative. An orange, or a pear, taken immediately on rising, will sometimes act as a laxative. In infants, after the fifth or sixth month, costiveness is usually an indication for introducing starchy substances into the diet.

Among hygienic measures, we may mention out-of-door exercise—in particular horseback riding; massage or kneading of the abdomen, which should be practised daily on rising, the manipulation being over the ascending, transverse, and descending colon, in that order. Electricity similarly applied has proved effective. It may be mentioned that tobacco-smoking acts with some persons as a laxative. The ingestion of a considerable amount of water is to be recommended, and a glass taken on an empty stomach in the morning is particularly effective. Mineral waters are, many of them, of value chiefly by attracting patients to ingest large quantities of fluid, which otherwise they would neglect to do. Some mineral waters, of course, have a distinct laxative character by virtue of their dissolved ingredients. Such are Hunyadi János, Friedrichshall, Congress, Carlsbad, Rubinat-Condal, Apenta, etc. Laxative waters that can be drunk on the spot, *i.e.* among diverting and pleasant scenes and society, are particularly useful. One to five glasses daily, according to the strength of the water, may be required.

The drug treatment requires caution. Purgatives are almost never indicated, except, perhaps, once at the beginning of a course of treatment. Laxatives in the form of mineral waters, just alluded to, or salines, magnesia, potassii et sodii tartras, etc., may be given in small repeated doses if necessary. Probably no better drug exists for the treatment of chronic constipation than aloin, which acts specially on the lower bowel, and but little upon the secretions. This should be given in small doses (say 0.01 to 0.02 gm. gr. $\frac{1}{6}$ to $\frac{1}{3}$ in pill; two pills to be taken two or three times a day). Unlike other cathartics, this does not require to be increased in dose to maintain its effect, but one pill can be dropped at a time till the motions are natural. Phenolphthalein in doses of two to five grains for adults, and three-fourths of a grain for children is of some value, but must be classed as a purgative. It is best given in tablet form, combined with belladonna and strychnine. Belladonna in the form of the extract, 0.01 to 0.015 gram (gr. $\frac{1}{6}$ to $\frac{1}{4}$), once or twice a day, is highly recommended. Nux vomica and strychnine have given good results, but are most reliable when combined with other remedies. They act not as cathartics, but probably by increasing the reflex irritability of the spinal centers which preside over peristalsis. The buckthorn (*Rhamnus frangula*) has been advocated, and cascara sagrada (*Rhamnus purshiana*) in the form of the fluid extract, in doses of two grams and over (℥ ss.) is very serviceable. The latter drug is also used in the more palatable form of compressed tablets, with or without aloin and nux vomica. Cold- or hot-water injections may be practised daily as an adjuvant to other treatment; suppositories of glycerin or of soap immersed in oil are sometimes effective, especially in children. Finally, in cases of obstinate rectal impaction, mechanical removal of the feces by the finger or by a scoop may be necessary.

Charles F. Withington.

**Contagion.**—The word contagion has been defined as the communication of disease by mediate or immediate contact. A disease thus communicable is called a contagious disease and the substance by which

the disease is communicated, the virus, is called the contagium. These terms are gradually going out of use as the knowledge of bacteria and infection is becoming disseminated. The old distinction between a contagious and an infectious disease has been wiped out and it is recognized that all diseases which are caused by microorganisms, that is infectious diseases, are more or less communicable and therefore to that extent contagious. The term communicable disease is preferable to contagious disease as it more clearly indicates its meaning.

Contagion may be immediate when a disease is transmitted by direct contact of the victim with the patient. It becomes mediate when some inanimate article or some other person is the means by which infectious material is transferred from the patient to the victim. Thus the transmission of typhoid fever by infection of drinking water with the stools of typhoid patients would be mediate while the transmission of measles by casual association would be immediate contagion. The possibility of the transmission of infectious diseases by means of clothing worn by the patient or other articles handled by him has been a matter of discussion but certainly occurs within certain limits. The so-called innocent syphilis is an illustration of this form of contagion.

Ralph G. Stillman.

**Contractility.**—Contractility is one of the fundamental and inherent properties of living matter. Nearly all of the movements which are so characteristic of living nature are due to this property; that is, they are due to the contraction of protoplasm.

The contraction of a body or of a substance implies an alternating compensatory expansion or relaxation. If it were not for the alternating contraction and expansion (or relaxation), a repetition of a movement could not occur, and the end for which contractility seems to exist could not be accomplished.

Contraction is active, while relaxation is passive. Contraction can be accomplished only through a catabolism of the living substance, while relaxation involves no catabolism and may take place at the same time with anabolism.

I. The Significance of Contractility.—Contractility in its most primitive form is possessed by the active protoplasm of unicellular plants and animals. In a more advanced form it is the property of more or less specialized portions of the metaphyta and of the metazoa. The active protoplasm of higher plants forms so small a portion of the plant body, and the activities of this portion are so obscured by the more prominent and apparent portions of the plant, that one is likely altogether to lose sight of the importance of contractility in the plant kingdom.

On the other hand, the extreme prominence of this property and of the highly specialized muscular tissue which manifests it in the higher animals leads the casual observer to associate contractility with the animals, and to look upon it as one of the characteristics distinguishing animals from plants.

Being an inherent property of living matter, contractility must have a significance which bears a fundamental relation to life.

Only through the study of primitive forms can one elucidate these problems of life. Let us suppose that one has before him under a microscope an ameba just taken from an aquarium (Fig. 1536). When first seen under these conditions, the organism is likely to be a fairly compact subspherical grayish mass. Presently one sees a portion of the mass slowly extending out from the main body. Other portions may extend out in other directions. These extensions or pseudopodia seem to be feelers. Through them the organism seems to get information regarding its immediate environment. Presently one of the pseudopodia gets rapidly larger through a flowing of the protoplasm into the growing pseudopodium from the cell body and its other extensions. In this way the organism moves across the field.

Should it by accident or otherwise come in contact, at any part of its periphery, with a small solid body, such as a unicellular plant of smaller dimensions than itself, it immediately flows around the foreign body, thus engulfing it. A plant body thus engulfed or swallowed is actually digested and assimilated by the ameba.

If the glass slide upon which the organism is resting be jarred, or if in any way the animal is suddenly stimulated, it quickly draws up in a spherical mass, and remains thus contracted until everything is quiet and the way seems clear for another reconnoitering of the environment—another foraging tour.

Finally, after a preliminary period of rest the old ameba divides into two young ones, thus completely

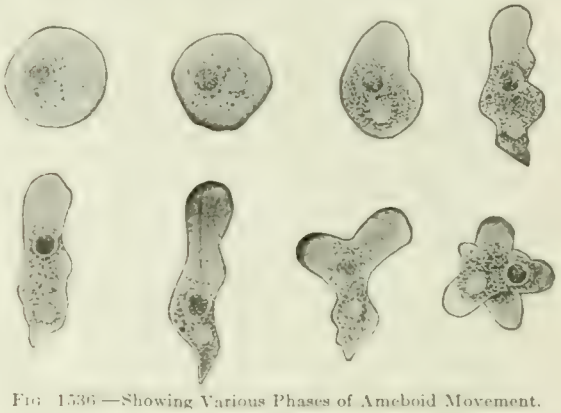


Fig. 1536.—Showing Various Phases of Ameboid Movement.

merging its individuality into that of the succeeding generation. This act of reproduction is accomplished through the means of a certain amount of contraction and movement.

The foregoing is, of course, an interpretation of the movements of the ameba in terms of the known activities of the higher animals, especially of man. How far this is justifiable is, of course, a question; but if we interpret the actions of low organisms at all we must of necessity do so in terms of our own experience.

Accepting this as a basis for our reasoning, we may say, then, that there are three fundamental ends served by the movements of the ameba: (*a*) nutrition; (*b*) protection; (*c*) reproduction.

In serving these three great realms of life activity, contractility stands in most intimate relation to the whole of life. If we study the higher ranks of living nature, we shall find that contractility holds just as important a relation to nutrition, protection, and reproduction as is observed in the protozoan.

II. The Structure of Contractile Substance.—It has been stated above that all living substance possesses the property of contractility as one of its inherent characteristics. It follows that the discussion of *the structure of contractile substance* is really the discussion of the structure of *living substance*. It is the intention of the writer to discuss in detail only those features of protoplasmic structure which are of especial significance in contractility.

Beginning with that substance which is most highly specialized as to contractility, viz., muscle tissue, one notes that the cell is a fiber and that the cell substance is fibrillated. In action it is observed that the cell becomes shortened in its long axis while its lateral dimensions increase, the volume remaining the same. The shortening of the muscle fiber (cell) is universally conceded to be the result of the shortening of the

fibrillæ, which take a prominent part in the structure of each muscle cell.

Each fiber or cell is surrounded by a delicate cell wall, the *sarcolemma*, shown in Fig. 1537.

In the figure the shaded areas (areas of Cohnheim) into which the cross-section of each fiber is divided, represent bundles of fibrillæ, *muscle columns*, which are separated by the sarcoplasm.

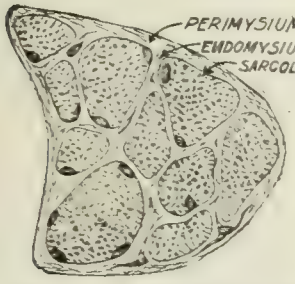



Fig. 1537.—Cross-section of a Fasciculus of Muscle. Note that each muscle fasciculus is surrounded by a sheath called the perimysium; that the fibers which constitute a fasciculus are separated from one another by endomysium, and that each fiber is surrounded by a cell wall called the sarcolemma. The dots just within the sarcolemma represent nuclei.

The proportion of sarcoplasm to fibrillar substance may vary enormously in the muscles of different species as well as in the different muscles of the same animal. "Those muscle fibers which serve the most persistent or most strenuous actions are richest in sarcoplasm." "The great pectoral muscle of the best fliers (among the birds) consists exclusively, or almost exclusively, of plasmic (rich in sarcoplasm) fibers, while in the weak-winged fowls it consists predominantly of aplasmic (poor in sarcoplasm) fibers." "There can be no doubt that energetic chemical changes go on in the sarcoplasm, as is proved by the frequent appearance within it of fat drops." "All indications favor the proposition that *the sarcoplasm* furnishes the pabulum which nourishes the fibrillæ during its activity." "If, then, it really is the rôle of the interfibrillar plasma (sarcoplasm) to preside over the nutrition of the contractile substance, the greater abundance of sarcoplasm in the muscles which serve the most strenuous and persistent functions is readily intelligible." (Quotations from Biedermann's "Electro-Physiology.")

Fig. 1538.—Portion of Fiber of Human Muscle. Note the transverse bands or striations. The light discs are divided by a dotted line (plane), first described by Krause and supposed by him to be a membrane.

The structure of the fibrilla has been under discussion for many years. Many of the points at issue are still unsettled. Fig. 1538 shows a human muscle fiber under high magnification. Note that the fiber presents alternating light and dark bands and that the light bands are subdivided by a fine dotted line. This line is called *Krause's membrane*, because it was at first thought to be a membrane. The whole fiber is composed of a great number of parallel fibrillæ. Each fibrilla is segmented and presents the same alternating dark and light segments shown by the fibers as a whole. Furthermore, each fibrilla possesses a portion of the "Krause membrane."

The most favorable material for the study of the finer structure of the fibrillæ is presented by the wing muscles of insects. Shäfer's preparations shown in Fig. 1539 give a very good idea of this structure. The portion between two Krause membranes is called a *sarcomere*. Note that in the extended condition the dark band has a light line dividing it transversely; this light line is called the line or plane of Hensen (see Fig. 1540, *A*, *h*). This plane of Hensen disappears when the fibrilla is contracted (see Fig. 1540, *B*, *h*). Each sarcomere then is occupied by dark and light matter. The dark matter seems to be more solid than the light matter. It is called a sarcous element or *sarcosome*.

From the figures given it is evident that the fibrillated structure of muscle protoplasm must play an important rôle in contraction. The attention has already been called to the fact that the muscle cell is composed of fibrillæ and sarcoplasm. Note from Figs. 1539 and 1540 that the fibrilla is, in turn, composed of a darker and a lighter portion, the *sarcosome* and the *sarcolymph*. The sarcosome seems to be of

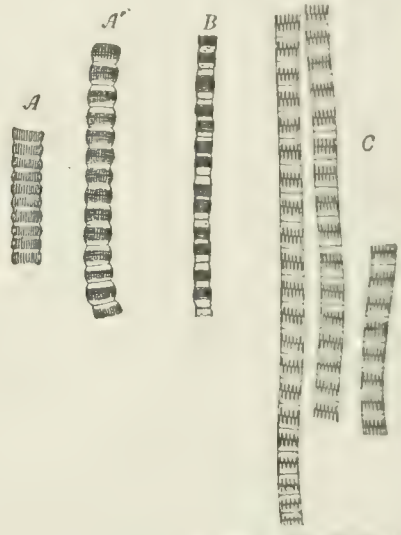



Fig. 1539.—Wing Muscles of an Insect. (After Shäfer.) *A*, contracted; *B*, same, relaxed; *C*, moderately extended.

greater consistency—that is, viscous; while the sarcolymph seems to be limpid in consistency. Not all of the substance of the fibrilla is contractile. The sarcosome is actively contractile, while the sarcolymph is passively adapted to the movements of the sarcosome, flowing to and fro in response to pressure from the sarcosome. Biedermann, cited above, has called attention to the fact that it is the sarcoplasm that serves as passive food for the active fibrilla. But within the fibrilla the passive sarcolymph probably serves as food for the active sarcosome.

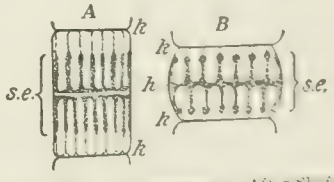



Fig. 1540.—Diagram of a Sarcomere. (After Shäfer.) *A*, Extended; *B*, contracted. The shaded portion [illegible] a sarcosome. *h*, Plane of Hensen. *k*, *k*, membranes of Krause. *s*, *e*., poriferous sarcous element.

In the muscle cell we seem to reach the highest order of differentiation in protoplasmic structure. It will be profitable to study less highly differentiated cells in the search of homologues to the structures above described.

Under favorable conditions and with sufficiently high magnification the protoplasm of animal cells is found to be composed of a meshwork of [illegible]. That portion of the protoplasm outside of the nucleus, viz., the *cell-plasm* or *cytoplasm*, is thus composed of substances representing at least two well-defined physical conditions, and belonging, without reasonable doubt, to two categories from a physiological stand-

point. The threads or fibrillæ which form the reticulum are of more viscous consistency, while the liquid which fills the meshes of the reticulum is more watery in consistency. The denser thread substance is called *spongioplasm*, while the liquid in the meshes is called *cytolymph*.

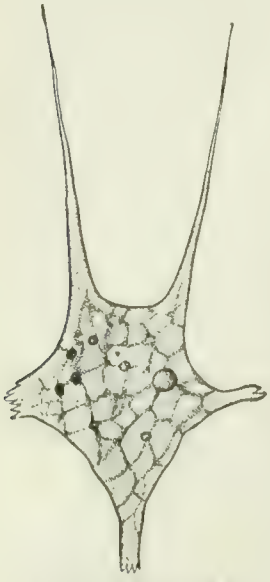


Fig. 1541.—Expanded End of a Foraminifer's Pseudopod. × 3,000. (After Butschli.)

A study of Figs. 1541, 1542, and 1543 will reveal all of these features in cells representing a wide range of differentiation in the animal kingdom.

This reticulated structure of protoplasm with its differentiation into spongioplasm and cytolymph is so general and constant that Wilson, of Columbia University, has made a diagram of a typical cell (see Fig. 1544) in which the reticulum in the cytoplasm is a prominent feature. The nucleus, centrosome, plastids, and metaplasm are of importance in any discussion of the cell reproduction and nutrition, but may be passed without further reference at this time.

There can scarcely exist a doubt in one's mind that the fibrillæ of a muscle cell are homologous to the spongioplasm, while the sarcoplasm is homologous to the cytolymph. The spongioplasm is not homogeneous, but consists of substances of different consistency, notable among the denser substances being the *microsomes* or protoplasmic granules. Though a homology may be traced between different features in the structure of the fibrillæ and those of the spongioplasmic threads, it is probably too early to venture a judgment on such a relation. This thing is certain: the cells which have parallel, contractile fibrillæ are lineal descendants of cells which possessed the spongioplasmic reticulum. Furthermore, the spongioplasm is active, while the cytolymph is a passive food supply, so that the analogy between fibrillæ and sarcoplasm on the one hand, and spongioplasm and cytolymph on the other, is perfect.

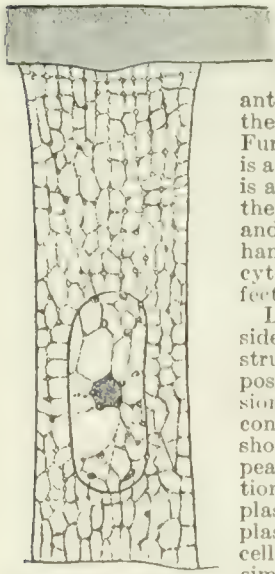


Fig. 1542.—Epidermal cell of an earthworm. × 3,000. (After Butschli.)

Let us turn briefly to a consideration of other contractile structures. The ciliated cell possesses permanent cell extensions—the *cilia*—which are in constant motion. Fig. 1545 shows the structure as it appears under favorable conditions. The fibrillæ of the cytoplasm represent the spongioplasm of the ciliated end of the cell. The cilia seem to be simple extensions of the cytoplasmic fibrillæ, interrupted at the cell border by a zone of microsomes, which, in Fig. 1546, are strongly suggestive of sarcosomes.

Biedermann's study of the property of contractility among the Ciliata makes it evident that in this class of unicellular animals we have a fibrillated structure in which the fibrillæ are also homologous to the spongioplasmic threads (see Fig. 1547).

The contractile substances thus far discussed are those which have the power of contracting in one particular direction. The Rhizopoda among one-celled animals, also the undifferentiated protoplasm of plant cells, possess the property of contractility, but the character of the movement is quite different from that of any of the animals above the Rhizopoda in that the contraction may take place in any direction whatsoever. This particular character of movement

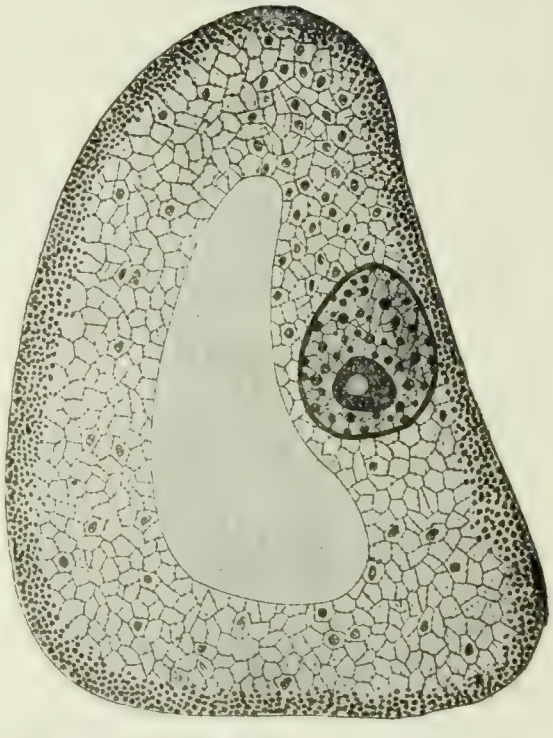


Fig. 1543.—Section through a Nephridial Cell of the Leech, Clepsine. (Drawn by Arnold Graf from one of his own preparations.) The center of the cell is occupied by a large vacuole, filled with a watery liquid. The cytoplasm forms a very regular and distinct reticulum with scattered microsomes which become very large in the peripheral zone. The larger pale bodies, lying in the ground substance, are excretory granules (*i. e.* metaplasm). The nucleus, at the right, is surrounded by a thick chromatic membrane, is traversed by a very distinct linin network, contains numerous scattered chromatin granules, and a single large nucleolus within which is a vacuole. Above are two isolated nuclei showing nucleoli and chromatin granules suspended on the linin threads. (Wilson: "The cell, in development and inheritance," 1896.)

is called ameboid (see Fig. 1536). The ameba, the monera, the leucocyte, and the protoplasm of plant cells do not seem to have a protoplasm differentiated into spongioplasm and cytolymph. The protoplasm of certain, perhaps all, foraminifera is, however, thus differentiated, and it is capable of typical ameboid movements and of no other kind of movements. Fig. 1541 shows the expanded end of the pseudopod of a foraminifer. The spongioplasm is very evident in the body of the expansion, but Bütschli has not shown it in any of the extensions. The literature of the subject would not lead one to believe that the fibrillar reticulum, met with in some of the animals endowed with ameboid movements, has any causative relation to those movements.

III. The Character of Contractions. As stated above, contractions alternate with relaxations. This condition is a physiological necessity, because con-

tractions are the result of catabolism, while relaxations take place during anabolism, though they are not necessarily the result of anabolism.

Contractions invariably decrease the surface of a body exposed to the surrounding medium, while relaxations as invariably increase the surface exposed. When an ameba relaxes it at the same time sends out one or more extensions of the body wall, thus increasing the surface, and through the increase of surface also increasing the absorptive area, and the opportunity to come into contact with solid bodies that may serve as food. With these two advantages there always comes the disadvantage that the expanded animal is subjected to greater danger of attack by other organisms, or of injury by the environment. Contraction decreases danger, decreases supply of nutriment and knowledge of environment. This seems to be a general law applicable to higher animals and to higher orders of individuals, *i.e.* to the municipality, the state, and the nation.

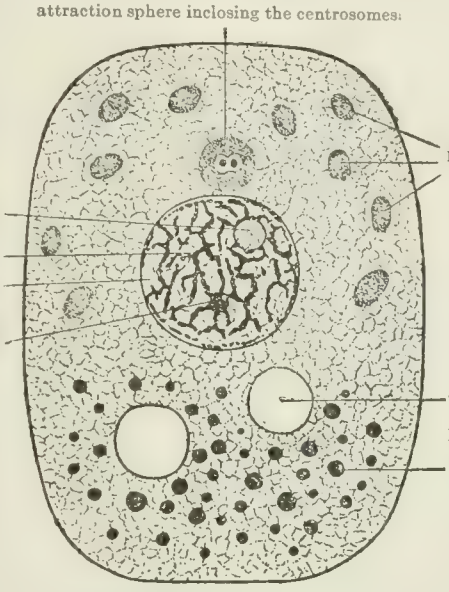



Fig. 1544.—Diagram of a Cell. (After Wilson.) Note that this diagram contains everything which a study of actual cells, as shown above, would seem to be essential and typical in cell structure.

*A. The Character of Ameboid Movements.*—Ameboid movements, so called because first observed in the ameba, are characteristic of the Rhizopoda in general, of leucocytes, and of some of the lower plant forms as well as of the unmodified protoplasm found in active plant cells.

The movements usually classified under this category differ slightly among themselves, and may be subdivided into the *flowing movements* which in plant cells become a distinct *circulation* of streams of protoplasm in the form of threads or strands of varying diameter from the region of the nucleus out to distant portions of the cell, usually along one side or through the middle, and returning along the opposite side or, in the latter case, along both sides. It is inconceivable that these movements could take place in protoplasm formed in part by a reticulum, much less that the reticulum could be active in causing the *flowing* and *circulation*. In this form of movement we probably have to do with the most primitive, spontaneous movements of living matter. That the terms contraction and expansion may be applied appropriately to this kind of movement is evident from the response which the protoplasm gives to any sudden, efficient stimulus it contracts into globular masses either along the course of the threads or around the nucleus (see Fig. 1548).

The other form of ameboid movement shown by the higher Rhizopoda and by leucocytes is characterized by a slow pushing out of a pseudopod from any point in the surface of naked animals, but from the foramina of the foraminifera.

The mechanism of this pushing out is a matter of interest. A pseudopod cannot be thrust out as a result of simple relaxation. Relaxation is passive, and passivity never pushes. We must then have to do with some other factor than simple relaxation. There is relaxation in one dimension only and contraction in the other two. When one thrusts his tongue out of his mouth the transverse muscle fibers contract, while the longitudinal ones relax. The result is a sudden change in the dimensions of the tongue; the longitudinal axis elongating at the expense of the transverse dimensions. Something analogous to this takes place in the pseudopod of an ameba.

What we call the contraction stage is a contraction in all dimensions. This leads to the assumption of the spherical shape.

Some, at least, of the organisms which possess the power of ameboid movement, possess also a reticu-

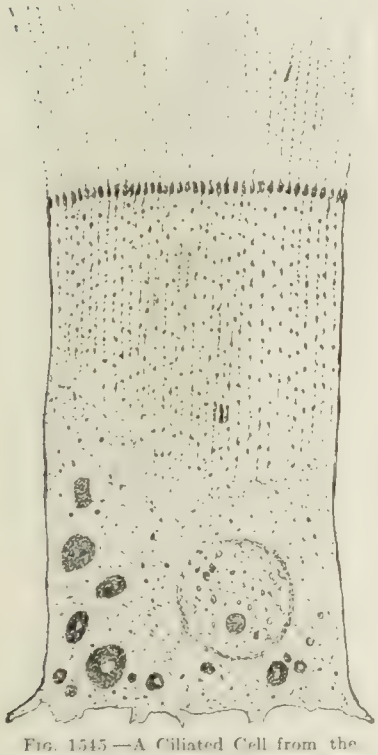


Fig. 1545.—A Ciliated Cell from the Intestinal Epithelium of Cyclas. Note the cytoplasmic fibrillæ terminating in a zone of peripheral microsomes to which the cilia are attached. (From Wilson, after Engelmann.)

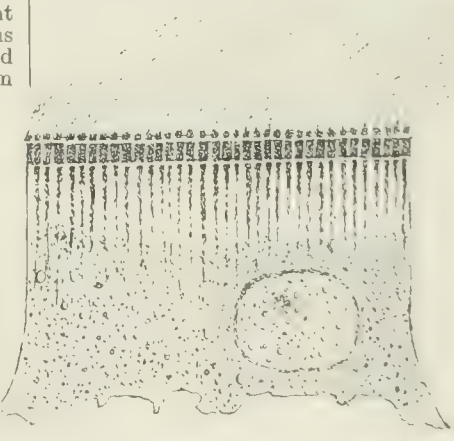


Fig. 1546.—A Ciliated Cell from the Gill of a Fresh-water Mussel. The cilia are contracted. (From Wilson, after Englemann.)

lated spongioplasm (see Fig. 1541). The threads of the reticulum lie in the three dimensions and, therefore, from a mechanical standpoint may cause the movements. Inasmuch as contraction in its higher differentiation is clearly the function of the fibrillated spongioplasm or its homologue, we are justified in searching for the beginnings of this differentiation as soon as we find contractility and fibrillated spongioplasm possessed by the same organism.

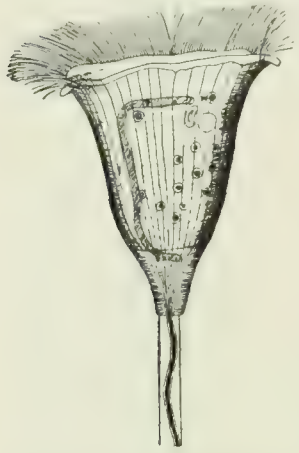


Fig. 1547.—A Vorticella (*Carchesium polypinum*). Note the converging fibrillæ developed from the exoplasm; also the muscle fiber of the pedicel.

*B. The Character of Ciliary Movements.*—In ciliary contractions we have for the first time an indubitable relation between fibrillated spongioplasm and contractility. Note that the contraction is transverse to the axis of the fibers (see Figs. 1545 and 1546). This can be accounted for only on the grounds of a contraction upon one side of the fiber or cilium, the other remaining relaxed (see Fig. 1549). (Verworn, *Allgemeine Physiologie*, p. 258).

Nobody seems to have raised the question as to how a cilium regains its erect position. Is it through a contraction of the opposite side or through elasticity?

The time and rhythm of ciliary contraction must be governed by the cells of which they are extensions, because all of the cilia of one cell contract in rhythmical unison. Upon ciliated surfaces all of the cilia act in harmony, sending a series of undulations over the surface similar to those which run over a field of wheat under the influence of the wind.

The ciliary contraction is strong and quick in one direction, while the relaxation is slow in the other; this results in a transportation, over the ciliated surface, of any bodies or matter which may be resting upon the surface, the transportation always being in the direction of the contractions.

Fig. 1548.—Showing the Protoplasm of a Stamen-hair Cell of Tradescantia. Expanded (*a*) and contracted (*b*).

The ciliated surfaces of the body are the respiratory tract below the larynx, the oviducts, and the vasa deferentia. The columnar epithelium of pharynx, esophagus, and small intestine in many of the lower vertebrates is ciliated; while in man there remains of this ciliated field only a sort of vestigial, nonmotile crown of short cilia upon the columnar epithelium of the small intestine.

The function of the cilia is evidently to carry secretions along a duct or passage, or, in addition to that, to remove foreign matter, as in the case of the cilia of the respiratory tract.

Ciliary contraction may be grouped in two classes: (1) Concerted, rhythmical, undulatory movement over a ciliated area; and (2) the whip-like movements of a single large cilium called *flagellum*. A good example of flagellate ciliary movement is found in the spermatozoon. The zoöspores of the algæ usually possess one or two flagella. The locomotion of a spermatozoon is a sculling movement.

*C. The Character of Muscular Contraction.*—Muscular contraction is characterized by the shortening of fibrillæ. We have already discussed at some length the minute structure of a muscle cell of some of the higher orders of animals. Biedermann ("Electro-Physiology," vol. i., pp. 3–5) traces the muscle fibrillæ phylogenetically back, through the whole invertebrate division of the animal kingdom, to the longitudinal contractile fibrillæ of the stentor and the vorticella (see Fig. 1547). In the case of the stentor the fibrils are separate throughout their course; but in the vorticella note that the separate fibrils of the exoplasm are gathered into the contractile fiber of the pedicel. The spiral course of this fiber down the inside of the elastic sheath of the pedicel causes the latter to be thrown into a cylindrical spiral when the fiber contracts (see Fig. 1550). Biedermann ("Electro-Physiology") demonstrated that a contracted vorticella returns to the expanded condition through the elasticity of the pedicel.

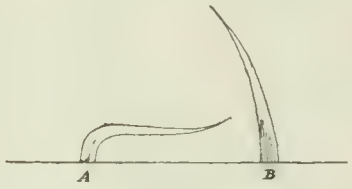



Fig. 1549.—Showing the Position and Condition of the Large and Slow-moving Cilia from a Rib of a Tunicate. *a*, stage of relaxation; *b*, stage of contraction.

Muscle fibrils never push; they are capable of active contraction of their longitudinal dimensions, but not of the transverse dimension to restore the original length. In this respect muscular contraction differs fundamentally from the ameboid movement. Muscle fibers may *contract and relax*, but they cannot *contract* and *expand*. During their condition of relaxation they are absolutely passive. They are, during this stage of their change, expanded; but the expansion depends upon the action of some factor outside of the fiber itself. In the case of the vorticella it depends upon the elasticity of the pedicel; in the case of the ciliary muscles of the eye it depends upon the elasticity of the tissues to which the muscles are attached; in the case of hollow viscera it depends upon intravisceral pressure; while in the case of the skeletal muscles the return to the expanded condition depends in part upon the elasticity of tissues and in part upon the active contraction of opposing sets of muscles.

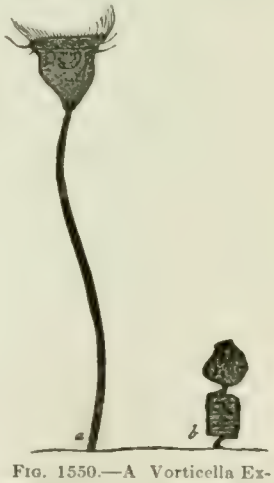



Fig. 1550.—A Vorticella Expanded (*a*) and Contracted (*b*).

Other topics on the subject of muscular contraction will be discussed in the article on *Muscle* (*q.v.*).

Winfield S. Hall.

**Contrexéville.**—Contrexéville, a spa of European celebrity, is situated in the Vosges Mountains southeast from Paris at a distance of about 230 miles from that city. The village and springs lie in a valley below the level of the surrounding country, at an altitude of 1,100 feet above sea-level. The "season" at which this resort is frequented extends from May 20 to about the first of October, and the climate at this time is temperate, with more or less of the characteristics of a

mountain resort; namely, sudden changes of temperature and cool or cold mornings and evenings, so that one must be provided with suitable clothing for protection against these sudden changes. There is considerable rain and cloud.

The character of the waters is earthy or calcareous, sulphate and carbonate of lime being the chief constituents, with minute quantities of the sulphates or carbonates of sodium, magnesium, lithium, and iron, and the chlorides of potassium and sodium.

It is a clear, still, almost tasteless water, with a temperature of 52° F. The chief and most important method of using these waters is by drinking, although baths, douches, and massage are also employed as adjuvants to their internal use; douches for the loins being a common method of application.

The special diseases for which these waters are used and success in which has made Contrexéville so famous, are those of the urinary organs, particularly gravel and renal calculous diseases, and the conditions resulting therefrom: pyelitis, pyelonephritis, and chronic cystitis. Gout and gouty conditions when dependent upon a supposed excess of uric acid in the system are also greatly relieved, and so also are gallstones, congestion of the liver, dyspepsia, diabetic gout, and such skin diseases as eczema, acne, or psoriasis, when the underlying cause is considered to be an excess of uric acid in the system. Nocturnal incontinence of urine in children is said to be benefited or cured by their use.

The principle of the treatment is internal lavage, the rapid passage of a large amount of water through the system, dissolving and carrying away toxic substances, and mechanically removing from the urinary passages sand, gravel, mucus, purulent secretions, etc. To accomplish these results, from one to six quarts of water are drunk daily, mostly in the morning from 4:30 to 9; some patients exceed this amount even to eight or ten quarts daily.

The immediate effect of the ingestion of this large amount of water is diuretic and aperient; the purgative effect occurs soon after taking the water and does not generally recur during the day. Drinking the water in the latter part of the day is not, as a rule, practised. The purgative effect sometimes fails and then recourse is had to a more definitely purgative water (Source Souveraine) or to a purgative; generally, however, this is not necessary.

The general plan of the patient's day is as follows: Taking the water in the morning from 4:30 to 9, the favorite time being about 7 A.M. Between glasses a short walk is taken. At 10 a substantial breakfast is eaten. Excursions, outdoor games, walks, etc., follow, and at 6 o'clock dinner is served. After dinner on certain days there are concerts and other amusements, and at 10 P.M. most of the invalids retire.

The contraindications are, in general, such conditions as are unsuitable for any spa cure, and especially the following: cancer and tuberculosis of the kidneys; cases of pyelitis and renal gravel with a continuously considerable amount of albumin in the urine; large calculi in the pelvis of the kidney; stone in the bladder; vesical paralysis with retention of urine; vesical tumors; extensive hypertrophy of the prostate; acute cystitis; cases of hepatic cirrhosis; cases of gout when an acute attack seems imminent or has just been checked by treatment; cases of diabetes with very large amounts of sugar, or complicated by nephritis or cirrhosis.

There are several springs, but the main one is the Pavilion, the waters of which are exported in large quantities.

The bath establishment possesses a fine park with gardens and pleasure grounds; and connecting with a central dome-shaped building, in which is the Pavilion Spring, are glass-covered galleries with shops, so that one can take the waters in rainy weather without being exposed. There are theatres, a casino, and many facilities for amusement and exercise. There are also pleasant drives and walks in the hills about. The hotels are good and of varying prices, and there are villas, furnished houses, and rooms to be obtained.

"The life is certainly monotonous and a trifle depressing," says Burney Yeo, but he adds, "the treatment is the end and object of being there," and in the maladies for which these waters are peculiarly applicable one can be assured of so much benefit that he can endure this monotony with equanimity when he finds himself recovering or greatly improving.

EDWARD O. OTIS.

**Contusions.**—See *Wounds*.

**Convalescence, Management of.**—GENERAL CONSIDERATIONS.—*Diet.*—Special details will be mentioned below. In most cases there is an indication for a fairly high protein ration, to compensate for atrophy induced by febrile toxemia, disuse of muscles, and interference with nutrition during the course of the disease or disability. But the protein ration should not usually exceed 100 grams; too much of it should not consist of meat; no one kind of meat or other food should be used on account of hereditary notions as to its superiority, at the sacrifice of variety or of the stimulation corresponding to special cravings; there should be no special attempt to employ chicken, squab, game, etc., especially as game is apt to be tainted or to have strong flavor or to excite repugnance, nor should there be any choice of white as contrasted with dark meat, of either fowls or quadrupeds; it should be remembered that oysters and clams are very dilute preparations of protein; that raw oysters are liable to be contaminated with typhoid and colon bacilli; that raw beef is liable to be infected with tuberculosis or infested with ova of tapeworm; that broths are very poor in nourishment and relatively rich in excrementitious, toxic products.

While the importance of protein cannot be gainsaid, it is equally necessary to remember the caloric value of carbohydrates and that there is no general objection to the use of sugar, in reasonable quantities, say up to 100 or even 150 grams a day, with due caution against fermentation.

The indication for fat, like that for protein, is liable to be overestimated. The mere loss of fatty tissue is not important and is often beneficial. Fat beyond 100 grams a day is subject to excessive waste in the processes of digestion and absorption. The catabolic products of fats, especially acids and acetone bodies, are, on the whole, much more toxic than derivatives from carbohydrates and even from proteins and accompanying extractives. Fat is actually deposited from the excess of carbohydrate and, less markedly, from that of protein beyond the daily needs of the body, more quickly than from feeding with fats themselves. Fatty foods are rather apt to cloy the appetite and cod-liver oil, even if it has any special value, often nauseates and prevents full nutrition. In children who apparently take it well, care must be exercised to make sure that it is not favored on account of the whiskey given with it in so many cases, even without the physician's order.

It is a good general rule to rid one's self and the family of the patient, of the notion that the diet of the convalescent must be peculiar. While care should, of course, be exercised in its selection and the preparation of the food to stimulate the appetite, it is unnecessary to go far outside the ordinary bill of fare. It is a very poor rule that the patient must never be consulted as to his meals and that anything which he particularly craves will prove injurious.

The use of alcohol is a serious problem in convalescence. One usually has to combat the notion of

some member of the patient's family or circle of friends that some form of wine is especially appropriate and the establishment of the alcohol habit must be guarded against, especially in young persons. Pharmacological experiment must also be depended upon to the extent of accepting the facts that alcohol is not a true direct stimulant, that its presence in the stomach contents beyond the amount of three to five per cent. of the total, inhibits digestion, and that it can rarely be oxidized beyond the total amount of thirty grams a day. On the other hand, small quantities, judiciously used, in a form empirically determined to stimulate appetite, often hasten nutrition.

Special indications for thyroid, nucleoprotein, iron, and mineral salts should be estimated as well as possible in the present undeveloped state of accurate standards and methods of determination.

Aids to digestion should be used intelligently, although formal analyses are often impracticable.

*Exercise.*—It is a good general rule, early in convalescence from almost any condition, to limit exercise to passive enjoyment of a change of environment, fresh air, and sunshine, avoiding too direct exposure to either cold, damp, wind, or sunshine. Gradually, exercise should be chosen to promote muscular restoration and stimulation of metabolism generally. It is not often wise to attempt to develop muscles not likely to be needed in the ordinary work and recreation of the individual and indoor, methodical gymnasium courses are not so good as more spontaneous, outdoor games, unless required for some strictly neurologic or orthopedic indication. Strenuous competitive games and sports should also be interdicted. However, it must be admitted that after pleurisy, with good general health, heart and arteries, violent exercise of the arms and shoulder girdle as in batting, cranking an automobile, putting the shot, etc., may break up adhesions. But it is a safe rule for the physician to assume no responsibility, in convalescence or otherwise, for athletic exercises in which the strain is not limited by the individual's line of safety but is graded according to an ever-increasing maximum. All forms of exercise should be adapted to the patient's tastes if possible. Some enjoy the sense of companionship and the peculiar rhythm of locomotion by horses and are rendered nervous by the thrill of an automobile. Others have an unreasonable hippophobia and a tachyphilia which can be better satisfied by the latter. Horseback riding, bicycling, rowing, etc., must be directed in accordance with the individual indications after fractures, accidental or operative wounds, the presence of hernia, arteriosclerosis, etc., remembering also the possible dangers incurred, especially by persons still weak or liable to attacks of unconsciousness as in epilepsy.

*Psychic influences* also deserve serious consideration. Nostalgia, worry over neglected business, inability to change long-established habits and, especially in young persons, disappointment at missing simple local pleasures, sea sickness and car sickness, often counterbalance the indication for change of scene. Sanatorium life during convalescence must be wisely adapted to the patient, not forgetting the tendency toward the enjoyment of chronic invalidism, engendered in some. The patient should not be subjected to the strain of uncongenial surroundings nor of association with uncongenial persons, not forgetting that very estimable and closely related persons may be an unfavorable factor. On the other hand, especially in young persons, the physician must guard against establishing habits of egoism, selfishness, and irresponsibility. At times, the irksomeness of the simple life and the disappointment at missing a pleasure, warrants an occasional mild social dissipation even if it involves comparatively late hours or an infraction of ordinary rules of diet. Eyestrain in reading, fancy work, or other manual occupations pursued to occupy the time, must be avoided, and the reading matter and forms of recreation of the patient must be supervised to avoid undue excitement of any kind. Various other details requiring attention will suggest themselves if the physician takes the pains to familiarize himself with the exact nature of the patient's routine and places himself in the patient's probable mental attitude.

Non-visceral Surgical Operations for Injuries and Non-emergent Lesions, the Patient's General Health being Good.—In such cases, the ordinary diet may be resumed in two or three days, simplified according to the diminished needs for energy, and especially if the nature of the operation or lesion (as a fracture preventing locomotion or some other condition) requires rest in bed. Overeating must be avoided, as there is a temptation to eat to pass the time and as many patients in hospital practice are suddenly placed in the midst of relative luxury. Unless locomotion will directly interfere with healing or there is some other special contraindication, exercise should be encouraged as otherwise there is a tendency to constipation often requiring cathartics. Salines should be avoided, partly because of their relatively reduced efficiency without exercise, partly because they tend to produce gastric subacidity. This may result in intestinal putrefaction and fermentation. Cascara, compound liquorice powder, tablespoonful doses of liquid paraffin, phenolphthalein, etc., may be used.

General anodynes should be used as little as possible, local agents, adjustment of bandages and splints, and, if necessary mild remedies such as dioscorea, helonias, cannabis indica may be employed. The high-frequency current is often sufficient. Neuralgia, neuritis, hysteria, syphilis, and rheumatism often account for pain and should receive diagnostic and therapeutic attention. Hypnotics should be avoided, especially as drugs mild enough to come under this heading are not very efficient. Rubbing, brushing the hair, bathing the face with cool water, heat to the feet, a light bed-time lunch, are often more efficient than hypnotic drugs. Complaint of sleeplessness is often due to the lack of realization that the patient becomes less fatigued than while in active life, that naps are taken during the day and that it is unreasonable to expect the usual period of unbroken nocturnal sleep. Restlessness, sleeplessness, and even hysterical pain or exacerbation of genuine pain, are often due to ennui or worry over neglected business, interruption of habits, such as smoking, nostalgia, etc. Some attention to business can usually be allowed, light occupation provided, smoking and other habits allowed in reason, and a sympathetic consideration of the patient's psychic state will often obviate the use of drugs. In some cases, especially in children and adolescents, the moral and psychic influence of establishing the habit of idleness is a serious matter. Useful reading, the pursuit of regular studies, needle work, basketry, kindergarten games, must be borne in mind as resources against this tendency.

It should be remembered that the atrophy of heart and voluntary muscles and the general metabolic stress of adjustment of all functions to a period of relative inactivity are important and must be opposed by regulation of permissible exercises, faradism, massage, diet, etc., and that caution must be observed when the patient is released from supervision.

Non-visceral Surgical Operations, not Directly Involving the Bodily Functions but Complicated by Intercurrent or Chronic Diseases.—This is too broad a subject to be considered in detail but must be dealt with in accordance with general principles and careful estimate of individual conditions. In many

cases, as after removal of a slightly diseased appendix with chronic typhlitis or general colitis, the enforced rest and opportunity for attention to diet and treatment of a neglected condition, apparently justify quite unnecessary surgical intervention.

The possiblility of acute gastric dilatation must be borne in mind, even after operation not directly due to or concerned with the alimentary canal. Most cases reported as postoperative, idiopathic gastric dilatation, may probably be explained as (*a*) preexisting dilatation, not recognized at operation, especially with the organ empty and with inadequate opportunities for inspection but becoming manifest as opportunities for distention develop; (*b*) cases of distention with secondary true dilatation, but of moderate degree, ultimately due to adhesions, traction, etc., or to reflex spasm induced by the lesion or the operation itself; (*c*) maximum distention without true dilatation, due to dietetic causes and states of depression of secretion and opportunities for fermentation and gas production, with pyloric spasm or to gas production from effervescence of gastric with intestinal contents with subsequent spasm of the pylorus or temporary obstruction of some nature, situated high enough to allow ballooning of the stomach.

Surgical Operations in which the Lesion or the Operation Directly Involves Certain Visceral Functions.—It should be clearly understood that the operator who assumes the responsibility of the after-care of such cases without expert advice from the appropriate internist, places himself on exactly the same plane as the medical practitioner who essays a capital operation for which he lacks proper equipment and training. Skillful operations, "successful" but resulting in death, have been due to overlooking thyroid failure, uremic poisoning, acid intoxication, with or without diabetes, starvation after gastrostomy due to "feeding" with inadequate quantities of proprietary liquids containing small percentages of protein and sugar. Other unpleasant possibilities might be mentioned but statements are limited to cases actually personally encountered.

In cases in which disease (cancer, ulcer, etc.) or resection or some -ostomy operation has produced actual lesions of the alimentary canal, feeding by mouth should usually not be attempted for a week or even longer. Inunctions of oil, nutrient enemata, hypodermoclysis with glucose added to physiological salt solution, can supply approximately half of the necessary calories and, under ordinary conditions, no anxiety as to life need be felt for a couple of weeks. The use of digestive ferments, HCl, the adequacy, digestibility, and time of administration of foods, the choice between swallowing and some method of intubation, through the esophagus to the stomach or duodenum, into the rectum or sigmoid, through -ostomy openings, and other problems require careful attention. In biliary fistula, the administration of food of proper amount and kind, and at proper times, as late in the evening, may favor drainage into the intestine and promote healing. Salivary fistulæ require suppression of secretion and the avoidance of sapid and odorous foods or others directly stimulating, for a considerable time. Pancreatic fistulæ present peculiar problems on account of the active digestant, practically escharotic nature of the secretion and its importance to nutrition. All operations on diabetics require careful management, largely because of the danger of concentrating the attention on the withdrawal of carbohydrates instead of remembering the necessity of eighty grams to prevent acid intoxication which is due, with or without diabetes, to fats and possibly proteins, and which requires for its detection careful titration of the urine and differential tests for acetone bodies, and administration of alkalies quantitatively regulated. When the kidneys are involved, by disease or by the operation, similar metabolic problems involving also the local actions on the urinary tract, present themselves. In more strictly genital surgery and even in cases not specifically involving the sexual organs, sexual stimulation must be avoided, by diet and even by such directions of tactful care as involve the reading matter and selection of attendants. So far as the heart and circulatory organs are concerned, the main danger is in the direction of overstimulation and unnecessary drugging suggested by a murmur. In senile cases and in those subjected to exposure and wet during operation, pulmonary conditions must be carefully looked for. Ether is usually considered as more dangerous in this respect than chloroform or the newer methods of anesthesia but this is by no means established and the difference may be due to the greater average exposure and dosage of patients with ether. The anesthetic itself may at times apparently precipitate an attack of acid intoxication unrecognized unless the urine is titrated. In some cases, vague symptoms following operation may be of the same essential nature as delirium tremens and, even if the symptoms are quite typical, they may be ascribed directly to the gross lesion, shock, anesthetic, etc. In such cases, the general contraindication of alcohol is more than balanced by its specific indication.

Cerebral and spinal lesions may precede various lesions demanding surgical intervention, or may be precipitated by the strain, shock, and intoxication of the anesthetic, etc.

Acute Infections.—To some extent, the best interests of the individual convalescent are opposed by quarantine restrictions necessary in behalf of the community. Unfortunately, rules as to duration of quarantine are somewhat arbitrary on account of absolute ignorance of the germ, as in the exanthemata, or difficulties in determining its presence or absence from time to time. So far as practicable, release from quarantine should depend on its demonstrated, permanent disappearance. The custom of certain boards of health to restrain diphtheria patients so long as any bacillus is found in the discharge should be modified by the application of specific tests for the diphtheria bacillus itself. In typhoid, quarantine should last until the feces and urine are free from typhoid bacilli for a reasonable length of time. The routine use of hexamethylenamine or some better substitute in typhoid, meningitis, and other conditions, is based on certain favorable bacteriologic results, while the use of external antiseptics in erysipelas as well as the disinfection of the premises, clothing, etc., seems even to prevent the danger of reinfection to some degree. While, at present, the use of antiseptics, especially those used internally for general infections, and those used locally for the exanthemata of whose germ causes and their distribution in the body, we are ignorant, is a blind attempt at obviating danger, it is probable that more definite information as to actual germ causes, the extent to which they penetrate the various tissues and their specific susceptibilities to chemicals, will ultimately reduce the problem of release from quarantine to fairly accurate methods.

Most acute infections are marked by some degree of renal congestion and a tendency to actual inflammatory change. This is especially true of scarlet fever and it usually held that the danger is greater after defervescence and during desquamation, but this may mean simply that avoidance of exposure to cold is easier while the patient is in a febrile state and confined to bed than while up and tempted to incur various risks. Attention to diet is equally important for the same reason and it should consist mainly of milk and cereals with small amounts of fruits or fruit juices and jellies.

After *diphtheria*, the principal danger is from cardiac paralysis, other manifestations of toxemic neu-

ritis being less serious. Hence, for a considerable time after convalescence is apparently established, great care should be used in the matter of exercise and excitement, dietetic indiscretions, etc. There is also a tendency toward nephritis but, fortunately, not especially of the glomerular type as in scarlet fever.

After a sharp attack of *erysipelas* in an old man, the writer has noted the permanent disappearance of albumin and casts which had been present in the urine in all of several examinations made at intervals for a number of years.

After various forms of *meningitis* and involvement of the central nervous system by infectious processes, attention must be directed toward whatever paralyses remain.

After *smallpox* has defervesced, special attention is usually required only to avoid pitting, which is lessened by avoidance of scratching, requiring bandaging of the parts affected and of the hands, for children, applications of soothing salves, etc.

It is a safe rule, however, to guard the kidneys and heart in all infections in which fever has been high, or in which the course has been protracted, or in which special manifestations of toxemia have occurred. The frequent occurrence of cardiac murmurs of organic nature, so far as can be judged, in persons giving no history of rheumatism, indicates one or both of two explanations: that mild attacks of rheumatism in childhood receive inadequate attention, or that other infections are frequently followed by similar cardiac lesions and require the same avoidance of strain and exposure, dietetic management and alkaline treatment during convalescence.

*Influenza* and *measles*, less positively *pertussis*, apparently non-pneumococcic bronchitis and pneumonia, and theoretically pneumococcic pneumonia—the theory being opposed by empiricism—predispose to tuberculosis, so that there is an indication both for full feeding, respiratory hygiene, and general tonic regimen, and for carefully avoiding exposure to human cases, fomites, and opportunities for implantation of bovine bacilli from milk and raw beef. The last item is especially important on account of the prevalent opinion as to the superiority of beef over other meats and of the custom of using raw meat as a reconstructive in convalescence.

After *yellow fever*, especial attention must be given to the condition of the liver, avoiding alcohol, foods rich in purins, spices, and maintaining the alimentary canal free from putrefaction and fermentation, by careful attention to details.

After *dysenteries* and *choleraic diseases*, the stools should be repeatedly examined for occult blood and indications of intestinal inflammation and indigestion and appropriate treatment should be instituted.

After *mumps*, especially in girls who have reached or are expected to reach puberty, especial care should be exercised with regard to chilling and excessive exercise, with a view to prevent the development of lesions of the sexual glands.

Generally speaking, a liberal diet but carefully balanced with regard to protein, carbohydrate, and fat and not too much in excess of the normal standard, should be instituted as soon as possible after defervescence, from any fever. Especial care as to digestibility and the actual digestive powers should be observed, if the lesions have involved the alimentary canal. After typhoid, it is usually held that solid foods should be withheld for a week or more after defervescence and that the diet should be very gradually increased throughout the next three or four weeks, the gravest fears being entertained of relapse, or of fatal hemorrhage, from allowing the patient to satisfy his appetite or to take even a small morsel of solid food too early. These fears are probably exaggerated. If the patient has been fairly adequately nourished and has been kept free from complicating intestinal putrefaction and toxemia, by using cereals with milk during the fever, the diet may be increased more rapidly and it is altogether improbable that hemorrhage, much less perforation, can be directly caused by a morsel of soft fruit, bread, etc., as is so commonly held.

A. L. Benedict.

**Convallaria.**—Lily of the Valley. "The dried rhizome and roots of *Convallaria majalis* L. (fam. *Liliaceæ*," (U. S. P.). This familiar and favorite little flowering plant, a native of many parts of the northern hemisphere, and everywhere cultivated, has been on the list of medicines and in the pharmacopœias for generations. Its flowers and rhizomes have both been used, and possess similar properties. The latter is alone recognized by our Pharmacopœia, while the flowers are recognized in the National Formulary. Convallaria is thus described by the Pharmacopœia: "Of horizontal growth and somewhat branched, about three millimeters thick, cylindrical, wrinkled, whitish, marked with few circular scars; at the annulate joint with about eight or ten long, thin roots; fracture somewhat fibrous, white; odor peculiar, pleasant; taste sweetish, bitter, and somewhat acrid."

The peculiar constituents of lily of the valley are *convallarin*, a purging crystalline substance, and *convallamarin*, a bitter, half-crystalline whitish powder; both are glucosides, the former decomposing into convallaretin, and the latter into convallamaretin. Convallamarin is a rather active poison of the digitalis character; in small doses increasing the urine and strengthening the heart's action. Although less reliable and useful in cardiac weakness than digitalis, it is still worth remembering when that drug acts unkindly, or when, after it has been taken for a long time, it is desirable to change for a while.

Convallaria may be given in substance. Dose, gr. xv. (1.0), or one may prescribe, as is more commonly done, the same number of minims of the official fluid extract. The conditions which indicate the use of this remedy are the same as those which call for the employment of digitalis.

W. P. Bolles.

**Convolvulaceæ.**—(*The Morning-glory Family.*) Aside from the use of the sweet potato as a food and starch-producer, this family is of medicinal interest only because of the resinous substances yielded by the tubers and tuberous roots of a number of species, and used as purgatives. The most important of these are discussed under the titles *Jalap* and *Scammony*. Others deserving of mention for the same properties are *Ipomœa pandurata* (L.) Meyer (Man-in-the-ground, Man-root: Wild Jalap), *I. orizabensis* (Pel.) Ledal (Male Jalap), *I. simulans* Hanbury (Tampico Jalap), *I. turpethem* Br. (the Turpeth of East Indian medicine) and *I. biloba* Forsk., also of India, which contains an alkaloid. The properties are not confined to the parts named above, as the stems and seeds of some species are used similarly.

Henry H. Rusby.

**Convulsions.**—A convulsion is a morbid condition characterized by acute, abnormal, irregular, and exaggerated muscular contractions.

Classification.—Some modern writers make the term convulsion synonymous with hyperkinesis, and thus include under it all the different clinical forms of abnormal exaggerated muscular contraction. This, is, however, an arbitrary extension of the common and accepted use of the word. The true relation of convulsions to the other hyperkineses is shown in the following table:

| | |
|---|---|
| The hyperkineses or spasmodic disorders. | Tremor<br>Cramp.<br>The myoclonias or twitching spasms (chorea, tic, etc.).<br>The myotonias or tonic spasms (tetanus, cramps, etc.).<br>Hypertonia (muscular hypertension, contractures, etc.).<br>Irregular tonic and clonic spasms occurring in seizures (convulsions). |

Thus the term convulsions does not include those forms of chronic hyperkinesis known as tremor, cramp, muscular tension, contracture, though the term convulsive is used in connection with very severe types of chorea and tic.

Convulsions, as indicated above, may be of a *clonic* character, that is, the muscles rapidly and irregularly contract and relax, or they may be of a *tonic* character, that is, the affected muscles remain persistently contracted for minutes or hours. Clinically we find that these two types are often combined, as in epilepsy. Convulsions may affect the voluntary or the involuntary muscles. In the former case they have been termed *external* convulsions, in the latter *internal*.

Convulsive affections of the involuntary muscles are, from physiological necessity, of a tonic character. Something almost like a clonic convulsion, however, occurs in postpartum uterine contractions, in colicky affections of the stomach and intestines, and probably in the movements of the stomach in vomiting. The spasmodic disorders of the involuntary muscles, as in asthma, vasomotor spasms, intestinal spasms, etc., are not generally considered under the head of convulsions, and the reader is referred to these special topics. The term internal or *inward* convulsions has become popularly applied to laryngismus stridulus. Convulsions, as regards their extent, may be divided as follows:

I. General convulsions.

II. Partial convulsions: (*a*) unilateral; (*b*) those affecting certain muscles or muscular groups, known as local spasms.

The term "spasms" has come to be used as a very general one, identical with convulsions. To avoid confusion, however, the reader should remember that older writers (Willis, Cullen, Linnæus) used the word spasm to designate the tonic form of convulsion; later writers, especially those of the French school (Savary, Georget, Brachet, Ferrand, Fauvel), define spasm as a convulsion of the muscles of organic life; while some German and English writers use the word when referring to localized convulsions.

A convulsion is only a symptom, and its presence may indicate in different cases very different pathological conditions. In many cases, however, the fact of the convulsion is about all that we know of the morbid state. In accordance with this we divide convulsions into the symptomatic, or those which are the expression of a tangible morbid change, and the idiopathic or essential. Practically we cannot perfectly carry out such a division, since convulsions are often caused by a morbid structural change or irritant, which is not determinable. As our knowledge of pathology has increased the terms idiopathic and essential are gradually being dropped, and the word functional has gradually taken their place, when the cause still remains unknown. It is customary, however, when an organic lesion is known to be at the bottom of those convulsive attacks, which are ordinarily functional, to indicate the fact by some change in the terminology. Thus symptomatic epileptic convulsions are spoken of as epileptoid. Much confusion exists as to the terminology of the different pathological forms of convulsions. It is better, however, to adhere, as a fundamental distinction, to the division of convulsive disorders into only two types, viz., the functional or idiopathic and the symptomatic, while the much-used term reflex should be made a subdivision of these; for certainly the convulsions that result from a gross intestinal irritation or a pronounced blood poison are truly symptomatic. On this basis we make the following classification:

I. *Essential or Functional Convulsive Disorders.*—(*a*) Those of a general character: epilepsy, generalized tics, hysterical and hystero-epileptic or hysteroid convulsions.

(*b*) Those of a partial character: local epilepsy, local tics.

II. *Symptomatic Convulsions.*—*a*. Reflex, from wounds, injuries, inflammatory or other irritations of excito-reflex nerves. (*b*) Direct, from meningitis, brain tumors, hydrocephalus, focal brain lesions.

III. *Specific Infective Convulsions.*—Tetanus, tetany, rabies. There is such considerable confusion in the terms used by medical writers on this subject that the following further explanations are necessary. Eclampsia in infants is in many cases only symptomatic. In other instances, however, no known direct or reflex cause exists, and these form the genuine "functional, or epileptic" convulsions. In puerperal eclampsia, also, there is often a toxic agent at work, of which the convulsion is the clinical expression; but at other times it is a true convulsive neurosis. These true non-symptomatic cases of eclampsia have been called *acute epilepsy*.

It is very evident that, as pathological knowledge advances, the convulsive neuroses will be relegated to the categories of symptomatic, organic, or toxic diseases, *e.g.* epilepsy.

Etiology.—In studying the general etiology of convulsions I necessarily exclude tetanus and hydrophobia, which are markedly distinguished from the other forms.

*Predisposing Causes.*—There is a certain unstable condition of the nervous system which predisposes toward convulsions. The nerve cells are like a too inflammable tissue, which flares out at the smallest spark. The state may be spoken of as one of convulsibility. This "convulsibility" is greatest during the first two years of life, during which time eclamptic attacks are most frequent. It then falls till the fifth year, to rise again as puberty approaches. During these years, from six to sixteen, most cases of epilepsy develop. Convulsibility then gradually declines, and few cases of the convulsive neuroses arise after the age of thirty. Convulsibility is somewhat more pronounced in girls and women; and is heightened at the menstrual periods and climacteric. It is, as a rule, lessened during pregnancy, and is increased by sterility in women, and by sexual excesses or depletions in both sexes. The convulsive diathesis may be inherited, connate, or acquired. It is inherited in about one-third of the cases from ancestors of a neuropathic or tuberculous constitution. It is connate as the result of frights, injuries, or nutritional disturbances received by the pregnant mother; perhaps also as the result of intoxication of the father during the sexual act. Convulsibility is acquired, in the young, by infectious fevers, bad food and air, chronic diarrhea, hemorrhages, and by rickets. As the child grows older convulsibility may occasionally be developed by bad systems of domestic and school training, and overindulgence in emotion. At this time psychic trauma and bad mental habits start up subconscious states which are the source of psychogenic convulsions. At the time of puberty the abuse of the sexual function, great excess in the use of alcohol, tobacco, and absinthe, worry, fright, and mental strain, come into play. After manhood or womanhood is fully reached, it is only by the powerful and persistent action of depressant and disturbing forces that a convulsive temperament is acquired. Latent

tendencies may, however, be brought out at this period.

Climate and season have a slight influence over convulsibility. Tetanus occurs oftener in cold weather; epileptic attacks occur oftener in the spring and autumn and on wet, cloudy days, and these diseases are more frequent in temperate climates.

Race is undoubtedly a factor in predisposing to convulsions.

*Exciting Causes.*—These are very numerous, but vary in character chiefly with age. For details on this point the reader is referred to the special articles. Here it can only be said that in infancy the most frequent exciting causes are: pressure on the brain from meningeal, hydrocephalic, or hemorrhagic effusions, injuries at the time of birth: blows, acute infection, fright, and dental or gastrointestinal irritations. At an older age we find sunstroke, sexual irritations, intemperance, syphilis, the puerperal state, as active factors. Still later, cerebral tumors or hemorrhages, and injuries to the skull are potent.

Physiopathology.—For the special pathology of the convulsive neuroses, the reader is referred to the special articles on these diseases. There are certain facts in the mechanism of their production, however, which are common to all. In a convulsive attack there are brought into functional activity—

1. A nerve center, which is discharging its force with excessive violence, due to overstimulation or lack of inhibition.
2. Outgoing or efferent neuraxones.
3. Their peripheral end plates, and the muscle or end organ.
4. Afferent excito-reflex neurones, carrying excitations to the irritable center, or afferent inhibitory neurones which lose their grip on the motor centers.

In order that a convulsion may occur, the nerve center (1) must be unduly irritable or unduly stimulated or inadequately inhibited, until it is made unstable; the other factors in the mechanism, (2) and (3), must be intact, and the convulsion will be favored by their being in an overirritable state.

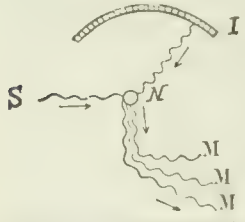



Fig. 1551.—Diagrammatic Illustration of Convulsions. I., controlling center; N, motor nerve center, from which neuraxones run to M, groups of muscles, and S, excito-reflex neuraxones. A convulsion may be caused by an over-irritation of N or of S, or by a depression or paralysis of I.

The agents which affect the nerve center (1), making it overirritable and explosive, are:

(*a*) Some inherent defect in cell nutrition.

(*b*) Some direct chemical or mechanical irritation, as in toxic convulsions, and in those caused by organic disease.

(*c*) Powerful excito-reflex or weak inhibitory impulses.

Local and limited convulsive movements may also be caused by irritation or interference in the regular conduction of the efferent nerves (2).

Certain parts of the cerebral nerve centers have an inhibitory action over the function of other parts, rendering the motor cells more stable and less liable to part unduly with their energy. A convulsion may result from a too great weakening or entire loss of this inhibitory force. In the developing and undeveloped nervous system of the child, the inhibitory powers are imperfect; hence a greater convulsibility at this age.

The part that the spinal cord plays in producing convulsions in man is not great and has been exaggerated. Eclampsia infantum, for example, is the result of a defective inhibition of certain higher brain centers upon lower. We see instances of true spinal convulsion (spinal epilepsy, spinal trepidation) in chronic diseases of the spinal cord implicating the pyramidal tracts, at the beginning of the third stage of anesthesia, and in infants, children, or sensitive adults just as they are dropping off to sleep.

Symptoms.—The general convulsions of eclampsia, epilepsy, hysteria, and hystero-epilepsy have common features. There are often symptoms, indicating an overirritable or depressed state of the nervous system. The attacks themselves come on suddenly, sometimes with an immediate prodromal symptom or aura. The muscular movements are irregular and incoordinated, except in some phases of hysterical and hystero-epileptic convulsions. Consciousness is generally abolished, as are also sensibility and the reflexes. Very marked secretory disturbances occur. The vasomotor system is greatly involved, especially that part which controls the blood supply of the brain. The face and probably parts of the brain are at first blanched, but the anemia is soon followed by pronounced passive hyperemia. In eclampsia infantum, however, the first sign of the impending attack is sometimes a cerebral hyperemia, and the convulsion may be arrested by pressure on the carotids. Respiration is disturbed, and the heart beats at first more slowly, then more rapidly than normal.

Diagnosis.—The diagnosis of a convulsion is easy. One has only to differentiate it from malingering. The state of the pupils, of the reflexes, and of the sensibility, and the want of art upon the part of the malingerer, are generally quite sufficient to clear up the case. As to the form of convulsion, the difficulty in diagnosis may lie first in determining whether an attack is one of eclampsia, of epilepsy, or symptomatic of some infection, of encephalitis or hemorrhage. Eclampsia occurs oftenest before the age of two years; the attacks are less sudden, more irregular, more prolonged, and less severe than in epilepsy. Usually there is no frothing at the mouth. After the age of two, convulsions are most probably epileptic. If the convulsion is due to hemorrhage or an infective inflammation (encephalitis) then will follow paralysis or some signs of focal lesion. It is important to distinguish between hysterical, hysteroid, and epileptic convulsions. All that I can say here, however, is that in the two former types the movements are more coordinated, consciousness is not often entirely lost, sensibility may be present, and hallucinations may develop.

It is very important to determine whether the convulsion is idiopathic, or symptomatic of some general disease, reflex irritation, or organic central affection (see *Chorea*, *Eclampsia*, *Epilepsy*, *Hysteria*).

In some forms of convulsions it is necessary to make an anatomical diagnosis. If the symptoms are in the main bilateral, the cause is to be referred provisionally to a cortical irritation or to the medulla; if they are unilateral, or involve special muscular groups, the convulsion is presumably symptomatic of a lesion in some part of the basal ganglia, or motor cerebral cortex of the opposite side.

There is a certain probability that convulsions in infancy are essential or infective; in childhood are meningitic, febrile, or epileptic; in maturity and old age are symptomatic of syphilis or structural lesions.

Prognosis.—As regards the attacks, the danger to life is greatest in infantile and puerperal eclampsia; next in the degree of danger comes the status epilepticus, then follow epileptoid convulsions, and epilepsy. As regards recurrence and final cure no general comparisons can be profitably made.

Treatment.—The general principles governing the therapeutics of convulsions are nearly the same for all. For the attacks, removal of sources of irritation, the use of chloroform, ether, morphine, amyl, nauseants,

bromides, and chloral are indicated. For the disease, removal of all direct or reflex irritants and a treatment calculated to lessen the irritability and increase the tone and nutrition of the nervous system are indicated.

In the convulsions of children the common and effective practice is to place the child in a warm bath. In convulsions of adults, when drugs cannot be given by the mouth, enemas of thirty to forty grains of chloral-amid are efficacious. In hysterical convulsions hypodermic injections of apomorphine, gr. $\frac{1}{8}$, or morphine, gr. $\frac{1}{4}$, may be given. CHARLES L. DANA.

**Cooper, Sir Astley Paston.**—Born at the village of Brooke, Norfolk County, England, on August 23, 1768. At the age of sixteen he was sent to London and placed under Henry Cline, Surgeon to St. Thomas' Hospital. In 1789 he was made Demonstrator of Anatomy at St. Thomas' Hospital; in 1791 he became joint lecturer with Cline in anatomy and surgery; and in 1800 he was made Surgeon to Guy's Hospital, on the death of his uncle, William Cooper. The Copley medal was awarded him in 1802 for two papers, read before the Royal Society of London, on the destruction of

FIG. 1552.—Sir Astley Paston Cooper.

the membrana tympani. In the first volume of the Transactions of the Medico-Chirurgical Society he published an account of an attempt which he made to tie the common carotid artery for aneurysm. After the publication of his great work on hernia (1804–1807) his reputation rapidly increased and his professional income became correspondingly large (over $100,000 per annum, according to the Encyclopædia Britannica). In 1817 he performed his famous operation of tying the abdominal aorta for aneurysm. He was made a baronet in 1820, shortly after he had removed a wen from the head of George IV. He died on February 12, 1841, in London, and was interred, by his own desire, beneath the Chapel of Guy's Hospital.

Of his published writings the following deserve to receive special mention: "Anatomy and Surgical Treatment of Hernia," 1804–1807; "Dislocations and Fractures," 1822; "Lectures on Surgery," 1824–1827; and "Illustrations of Diseases of the Breast," 1829. Sir Astley Cooper's influence upon American surgery must have been great, for nearly all of our prominent surgeons of the first half of the nineteenth century—William Gibson, of Philadelphia, Paul F. Eve, of Nashville, Tenn., Valentine Mott, of New York, and John Collins Warren, of Boston, not to mention the names of many other men less widely known—are reported to have been his pupils. A. H. B.

**Copaiba.**—BALSAM OF COPAIBA. An oleoresin obtained from several South American species of *Copaiba* (fam. *Leguminosæ*). At least seven species of Copaiba are known to yield the drug, as follows: *C. langsdorffii* (Desf.) Kuntze, *C. confertiflora* (Benth.) Kuntze, *C. coriacea* (Mart.) Kuntze, *C. oblongifolia* (Mart.) Kuntze, all of Brazil, *C. officinalis* Jacq. in the Orinoco valley, and *C. guyanensis* (Desf.) Kuntze and *C. multijuga* (Hayne) Kuntze of the Amazonian region.

Several species furnish ornamental woods for cabinet work, the so-called "amaranth," or purple wood, being one of them. The timber is also highly prized for boat and wheel making in tropical America, and the seeds are used like vegetable ivory for small objects.

COLLECTION.—The stems of the copaiba trees contain numerous oil canals and cavities, in which the liquid is accumulated as turpentine is in those of the pine trees. But the copaiba canals are much larger, sometimes even exceeding an inch in diameter, and they traverse the whole length of the stem. Into these the copaiba is freely secreted. Indeed, the pressure of it in them is said to be sometimes so great as to split the trunk itself and to find spontaneous exit, as is also true of one or two other oleiferous trees. As may be supposed, the process of collection is simple enough: a deep gash cut into the trunk, reaching the heart-wood, hollowed and slanting below so as to collect the flow, provided with an improvised spout made from the bark itself, or with a leaf, and a receptacle to contain the oil as it flows in a steady stream, are the essentials. It is carried on mostly by the Indians. The yield is enormous, and may reach from ten to fifteen gallons from a single tree.

The principal amount, as well as the finest quality of this drug is exported from Pará, in Brazil, generally in barrels. Other Brazilian ports, as well as Angostura, Cartagena, Maracaibo, and Trinidad, also export that which is collected in their respective neighborhoods. The products of different countries vary a little in their sensible qualities, and are, in trade, designated by their geographical names; that of Pará is thinner and paler, and rotates the polarized ray to the left; those of Venezuela and Trinidad are thicker and brownish, and rotate to the right. Some species are, moreover, opalescent, others perfectly clear. There is the greatest difference in their medical efficiency.

Copaiba has been known in Europe something more than 250 years. Its usefulness was learned from the aborigines of Brazil, among whom it was highly esteemed.

DESCRIPTION.—The consistence and color of this substance, although probably depending in part upon its natural amount of oil, vary also with age and exposure, becoming thicker and darker as the oil evaporates. Fine fresh Pará copaiba is a clear liquid, about as thick as Canada turpentine, and of about the same color. It is often darker, however, and may have a deep golden yellow, or even a sherry tint. Copaiba has a peculiar, aromatic, somewhat terebinthinous odor, and a persistent, bitter, biting, disagreeable taste. Its specific gravity varies from 0.916 to 0.993, and it is soluble in absolute alcohol and in four times its bulk of petroleum spirit. Some varieties, as noted above, are not quite clear, and are sometimes fluorescent. In evaporating a small quantity, there should be no odor of turpentine, and the residue, when cold, should be hard and easily rubbed to powder. It should not boil under 482° F. and should rotate to the left 28° to 34°. Four drops, carefully added to a mixture of half an ounce of glacial acetic acid with four drops of nitric acid, should not afford a reddish or purple color.

COMPOSITION.—It contains from forty to sixty, or even eighty per cent., according to its [illegible] *essential oil* of the composition $C_{10}H_{16}$, $C_{15}H_{24}$, high boiling-point, and the odor and taste of the [illegible] itself. A good Surinam article contains seventy-

eight per cent. This is also official (*Oleum Copaibæ*, U. S. P.). The crude *resins* left behind in the distillation are somewhat employed under the name resin of copaiba, but the article is of little value. It is a brownish-yellow, brittle substance, with the appearance of common resin. It is a natural mixture of at least two substances. Copaiba is apt to be adulterated; one of the commonest additions is castor or some other fixed oil; Gurjun balsam, oil of turpentine, and other volatile oils are also sometimes added.

Action and Use.—Large doses of copaiba occasion vomiting, purging, and colic, symptoms due to its locally irritant action upon the alimentary canal; they also may cause some difficulty in micturition, with burning pain in the urethra, or even strangury, but the latter is rare. Copaiba is mostly eliminated with the urine, which it increases and changes in odor. According to Brunton, "it forms a conjugate glycuronic acid in the system, and is eliminated in the urine, which with nitric acid gives a precipitate of copaibic acid, easily mistaken for albumin, but distinguished by disappearing on the application of heat. The conjugate acid renders the urine antiseptic, as it is secreted by the kidneys, so that it does not readily decompose, and bacteria either do not appear in it at all or only in very small numbers, even after the surface has become covered with mould." This, if true, may explain at least a part of its usefulness in the urethral and vesical catarrhs, for which it is so much employed. Its elimination products, if sufficiently diluted, appear also to be soothing to the lining membrane of the urinary tract. A portion of the copaiba taken makes its exit from the lungs, as shown by the breath. The principal call for this medicine is in catarrhs of the genito-urinary system, especially of the urethra and bladder. In gonorrhea and gleet, its employment at one stage or another is almost universal. In chronic vesical catarrh it is also sometimes useful, and more rarely so in chronic bronchitis. Its value in chronic diarrhea and dysentery, and as a diuretic in cardiac dropsy, is more doubtful. In the acute stage of the above affections, it is not to be advised. An erythematous eruption occasionally appears during the use of the medicine; this, however, departs as soon as the drug is omitted.

Administration.—The oleoresin itself is generally given. From ♏ x. to xx. (0.6–1.3) three or four times a day, is the usual dose. Dropped upon a lump of sugar, it can be quickly chewed and swallowed, or an emulsion can be made of it flavored with syrup of acacia or yolk of egg. In either case its taste is very disagreeable and persistent. It may be solidified by adding six per cent. of magnesia (Massa Copaibæ), and made into pills, but the value of this preparation is doubtful. A sort of soap may be made by adding enough *liquor potassæ* to cause it to mix with water. More than by all these methods, it is at present given in gelatin capsules. H. H. Rusby.

**Copal** (Including *Animi* and *Kauri*).—This name is applied to a number of resins of similar nature, but of widely different origin, both botanically and geographically. As the article is only of mechanical interest, and the different varieties are so similar, they need not be discussed here. It is mostly dug from the ground in a fossil condition, though the trees yielding at least most of the varieties are still in existence. Copal is very hard, of glassy or splintery fracture, of various shades, from light yellow through reddish-orange to dark reddish-brown, and usually translucent, though sometimes milky or smoky. It may be smooth or dusty or (the best variety of animi) very warty. It occurs in pieces varying from the size of a marble to that of a mass weighing many, in one case several hundred, pounds. It is without odor and taste and the ordinary solvents of resin dissolve it only with difficulty. Its uses are purely for varnish and other mechanical coatings.

Henry H. Rusby.

**Copperhead.**—A very poisonous snake, *Ankistrodon contortrix*. The sharp fangs are hollow, so that poison is injected directly into the wound made when the snake bites. A. S. P.

**Copra Itch.**—An eruption of the skin caused by the mite *Tyroglyphus longior*, variety *castellanii*, which frequently infests copra. See *Arachnida*.

A. S. P.

**Coptis.**—Goldthread. The rhizome of *Coptis trifolia* (L.) Salisb. (fam. *Ranunculaceæ*). This plant is a pretty little evergreen bog-plant, with long, bright-yellow, thread-like rhizomes; bright-green and shining ternate leaves, and white, solitary, star-shaped flowers. It grows rather abundantly in the cold bogs of America, Europe, and Asia. The whole plant is generally collected, although the rhizome is undoubtedly the most efficient part. The description of the plant given above is sufficient for the drug, which has an intensely bitter taste, but no odor. The color, taste, and medicinal value of goldthread are due to a salt of the alkaloid *berberine*, which it contains in considerable quantity. A second alkaloid, *coptine*, is described by Gross as also present, but does not affect the medicinal properties of the former.

Goldthread is a simple bitter. It is frequently used in the country as a mouth wash for aphthous and herpetic ulcerations, etc. The ordinary dose is gr. xv.–lx. (1.0–4.0).

The root of *Coptis teeta* Wallich, of Asia, is a classic remedy for sore eyes, and still used in the Orient. Its properties are similar to those of goldthread.

W. P. Bolles.

**Copulation.**—See *Coitus*.

**Coral Bean.**—See *Poisonous Plants*.

**Coral Snake.**—The name given to snakes of the genus *Elaps*, found in the Southern United States. These snakes are banded with yellow and red; their fangs are grooved and permanently erect. The bites of species of this genus are not very virulent, and cause less serious trouble than those of other North American poisonous snakes. A. S. P.

**Cordylobia.**—A genus of flies, family *Muscidæ*, which contains a species, *C. anthropophaga*, whose larvæ sometimes occur as parasites in the skin of man. These flies are found in Africa. See *Insects, parasitic*.

A. S. P.

**Coriandrum.**—Coriander; Coriander Fruit; incorrectly, "Coriander Seed." The dried ripe fruit of *Coriandrum sativum* L. (fam. *Umbelliferæ*). The coriander plant is an annual European herb, also cultivated in Europe and the United States. Coriander is globular, and about four millimeters in diameter; crowned with the calyx-teeth and stylopod; brownish yellow, with slight longitudinal ridges; the two mericarps cohering and enclosing a lenticular cavity, and each furnished on the face with two oil tubes; odor and taste agreeably aromatic.

It contains about one-half per cent. of *essential oil*, eleven of *fat* (in the seeds), and fourteen of nitrogenous matters, etc. The only constituent of value is the oil (*Oleum Coriandri*, U. S. P.), a colorless or yellowish liquid, having the characteristic aromatic odor of cori-

ander, a warm, spicy taste, and a neutral reaction; sp. gr. 0.905 to 0.925 at 25° C. (77° F.). *Linalool*, or *coriandrol*, and *pinene* are the constituents.

Fig. 1553.—Coriander Plant, one-tenth natural size. (Baillon.)

Fig. 1554.—Fruit of Coriander, natural size.

Coriander is a very mild and agreeable carminative, of the same properties as anise. Dose ʒ ss.–ij. (2.0–8.0); of the oil, ten drops or so—on sugar or suspended in syrup or mucilage. There is no official preparation of either the fruit or the oil.

H. H. Rusby.

**Coriaria.**—A genus (fam. *Coriariaceæ*) of about ten species of shrubs inhabiting warm or tropical regions. The leaves and fruits of several of these are well-known poisons, both to man and to grazing animals. In the ripe fruit, the poison is said to be confined to the seeds. Their medicinal use has apparently not been tried, but they are of interest because the leaves of one, *C. myrtifolia* L., have been found as an adulterant of senna. They are readily distinguished by their three-nerved surface. The active principle is the glucoside *Coriamyrtin* ($C_{30}H_{36}O_{10}$), which is crystalline, tasteless, and soluble in both water and alcohol. Its action is very similar to that of picrotoxin.

Henry H. Rusby.

**Cornarius, Johann.**—Also known by the name of Hagenbut. Born in Zwickau, Germany, in 1500. An enthusiastic student of the Greek language. At the age of twenty-one he was elected Professor of Philosophy at the University of Wittemberg, and at that of twenty-three he was already a licentiate in medicine. Desiring to obtain a more thorough knowledge of the latter science he sought far and wide for copies of the writings of Greek medical authors, but was at first unable to find what he desired. On reaching Basle, however, he discovered, at the establishment of the celebrated printer Frobenius, a copy of the Greek version of Hippocrates, published by the Aldus family, of Venice; and, in addition, he found there the writings of several other Greek physicians. At the solicitation of Erasmus, who spoke in encouraging terms of the plan, Cornarius undertook to produce a new translation of the Hippocratic writings; the Latin one of Calvo, published in Rome in 1535, not having at that time crossed the Alps. He spent fifteen years upon this difficult piece of work, but the publication of this and other translations of Greek medical writers into Latin brought him great and lasting honor. He died March 16, 1558.

A. H. B.

**Cornaro, Ludovico.**—Born in Venice, in 1467. He was not a physician, and his name appears here simply because he wrote a widely celebrated treatise on the advantages of sobriety. Endowed from birth with a very feeble constitution he permitted himself, as a young man, to indulge in rather high living; and as a consequence he began to suffer, from his thirty-fifth year onward, from abdominal pains, colic, frequent attacks of gout, almost constant fever of a low type, insupportable thirst, etc. So long as he persisted in indulging in the pleasures of the table, the efforts of physicians to relieve him from his misery proved of no avail whatever. Finally, the intensity of his sufferings compelled him to change his manner of living. He adopted the plan of restricting himself to twelve ounces of solid nourishment per day, this nourishment consisting of bread, soup, the yolks of eggs, meat, fish, etc.; and at the same time he partook of only fourteen ounces of fluids. He was careful not to expose himself to extremes of heat or cold, he avoided violent exercise, sitting up late at night, etc. Under the observance of this régime he recovered his health in the course of a few months, and lived—without physical infirmities of any kind—to the age of ninety-nine years. He died at Padua on April 26, 1566.

His book, which was published in Padua, in 1558 (and a French translation by Sébastien Hardy, Paris, 1646), bears the title: "Discorsi della vita sobria nei quali, con l'esempio di se stesso, dimostra con quali mezzi possa l'uomo conservarsi sano fino all'ultima vecchiezza. Several English translations of the work have been published.

A. H. B.

**Cornea, Diseases of the.**—General Considerations.—The nature of pathological changes in any structure of the body must be profoundly influenced by its anatomical details and relationships. This is emphatically true with regard to the cornea. It is the only fibrous tissue of the body which is entirely devoid of blood-vessels. Its nutrition is carried on by the percolation of lymph streams from the vessels of the surrounding parts through its cellular interspaces. Its vitality is correspondingly inferior to that of many other tissues. The cornea consists normally of five layers. In front is the epithelial layer, consisting of about ten thicknesses of epithelial cells having the general arrangement of pavement epithelium, and continuous at the corneal limbus with the epithelium of the conjunctiva. Beneath the epithelium is a delicate homogeneous layer called Bowman's membrane. This is akin to hyaline substance, and is by some authors derived from the epithelium, and by others from the proper substance of the cornea. The latter constitutes the next and principal layer of the cornea. It is a connective-tissue structure, composed of a great number of layers of long flat fibers, having a very regular parallel arrangement, and between which are the corneal cells or corpuscles. Behind the substantia propria are the membrane of Descemet, a delicate membrane similar to Bowman's membrane; and the endothelial layer, composed of flat polygonal endothelial cells.

It is commonly stated that the cornea can be invaded by bacteria only after abrasion of its epithelial protection. There can be no question that bacterial infection is very greatly favored by loss of epithelium. It is stated by others that prolonged contact of the corneal surface with discharge containing either the gonococcus or the diphtheria bacillus is sufficient to cause an ulcer without preceding epithelial abrasion. It may be that a lesion of Bowman's membrane is necessary before bacteria can reach the substantia propria. Descemet's membrane also probably serves to prevent the passage into the anterior chamber of the germs which have ulcerated the substantia propria. When an infective process is estab-

lished, the bacteria travel laterally rather than from before backward, passing between the corneal lamellæ. Hence the importance of cauterizing the margins of an ulcer. An infection in the corneal tissue is resisted by the lymph streams from the periphery, and by leucocytes derived from the same source. When by the process known as positive chemotaxis the white blood corpuscles are drawn completely to the seat of infection, a ring of infiltration lies immediately around the ulcer; but where the chemotaxis is negative the ring of leucocytes lies oustide a ring of clear tissue which surrounds the damaged area.

Restoration of destroyed areas of Bowman's membrane never occurs. Moreover, loss of the fibers of the substantia propria is never replaced by the same kind of tissue, but by ordinary scar tissue. The defect is filled in by new connective tissue, which is in turn covered by new epithelial cells. The new substance lacks the regular arrangement of the normal cornea, and hence is opaque instead of transparent. If the loss of true corneal substance has been only slight the resulting opacity is thin, and is referred to as a macula or nebula. But if the substantia propria has been replaced by scar tissue to a considerable depth and over an extensive area, the result will be a dense white opacity known as a leucoma. The interference with vision depends on the density of the opacity and on whether it does or does not cover the pupillary region. The opacity resulting from deep injury to the cornea is also due to the formation of this opaque scar tissue. Slight cicatricial opacities, especially those occurring in early life, tend to become somewhat thinner and more transparent in course of time. Even if there is little or no appreciable loss of the corneal fibers, the surface becomes less regular than before, and accurate refraction of rays of light is interfered with.

In inflammatory processes of long duration or great severity, the blood-vessels in the surrounding tissues proliferate and send new-formed vessels into or over the cornea. In this way are produced the characteristic vascularity of pannus, of interstitial keratitis, and of some cases of phlyctenular inflammation.

Examination of the Cornea.—Careful inspection of the cornea with the unaided eye in good daylight will reveal decided lesions. But for the discovery of delicate changes, such as slight opacities, minute foreign bodies, slight superficial loss of substance, or small blood-vessels, lateral illumination and the use of a binocular magnifier (loupe) are much superior and often indispensable. Irregularities in the surface of the cornea may be studied by observing the reflection on the surface of the cornea of the frame of the window through which the daylight enters, or the reflection of the concentric rings of Placido's disc. Any irregularity of curvature produces corresponding distortions of the reflected image; or, if the surface has lost its smoothness or there is an epithelial defect, the reflection will be lacking at this point. Diminished transparency of the cornea is suggested by lack of distinctness in the view of the iris. Elschnig recommends that myopes should discard their glasses during examination of a patient's cornea.

An attempt should be made to determine the depth in the corneal tissues at which any changes made out are situated. This is often facilitated by comparing them with filaments of mucus or tiny air bubbles on the epithelial surface. Or calomel may be dusted on the cornea. It is often important to determine whether an area of infiltration belongs to a process which is or is not still active; particularly whether it represents an active ulcer or one that has healed.

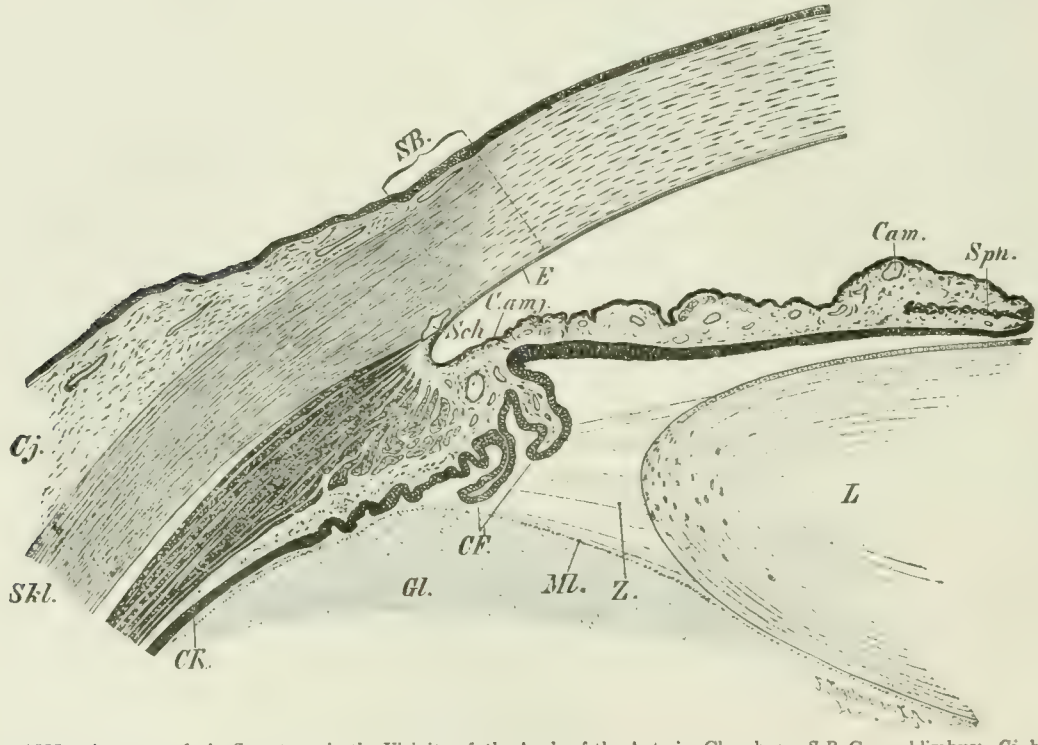



Fig. 1555.—Anatomy of the Structures in the Vicinity of the Angle of the Anterior Chamber. *S.B*, Corneal limbus; *Cj*, bulbar conjunctiva; *Skl*, sclera; *E*, endothelium; *C.K*, Ciliary body; *L*, lens; *Z*, zonule of Zinn; *GL*, vitreous; *CF*, ciliary process; *Ml*, membrana limitans of vitreous; *Sch*, canal of Schlemm; *Camj*, circulus arteriosus major of iris; *Cam*, circulus arteriosus minor of iris; *Sph*, pupillary sphincter.

This may often be decided by the presence or absence at the point in question of the reflections above referred to. If the reflection is present, the epithelial surface is intact, although it may cover a scar. If the epithelium is interrupted, the reflection will be absent. A very satisfactory means of detecting a superficial loss of corneal substance is to drop on to the cornea

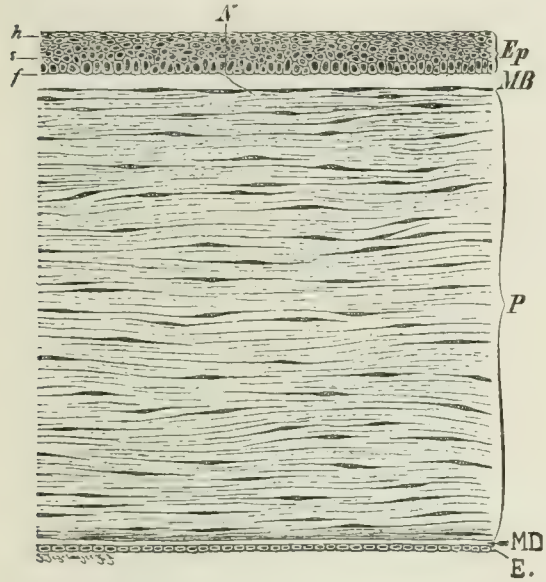



Fig. 1556.—Minute Anatomy of Human Cornea. *Ep*, Epithelium; *MB*, Bowman's membrane; *P*, substantia propria; *MD*, Descemet's membrane; *E*, endothelium; *N*, nerve canal; *f*, basal cells; *s*, prickle cells; *h*, flattened epithelial cells.

a very small quantity of a solution of fluorescein, washing off the superfluous stain with water. The healthy corneal epithelium is unaffected by the stain, whereas defects are clearly indicated by a greenish yellow staining. Methylene blue is used for the same purpose.

Phlyctenular Keratitis.—This is the same disease as phlyctenular conjunctivitis. But the symptoms

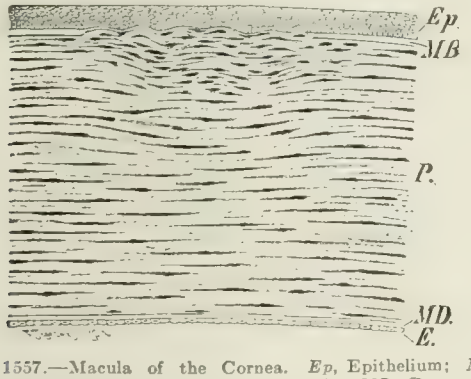



Fig. 1557.—Macula of the Cornea. *Ep*, Epithelium; *MB*, Bowman's membrane; *P*, substantia propria; *MD*, Descemet's membrane; *E*, endothelium of Descemet's membrane. (Elschnig.)

are usually more severe when the lesions affect the cornea, and the disease only becomes serious in its effect on the vision when the cornea is involved. Quite commonly, both conjunctiva and cornea are simultaneously affected. The lesions consist usually of small nodular infiltrations which break down to form ulcers. Sometimes the epithelium is raised by a tiny bleb, which ruptures after a short time. In some instances the disturbed area consists from the first of an infiltration which displays no tendency to ulcer formation. The phlyctenules are occasionally single, but generally multiple. They occur on any part of the cornea, but favor the neighborhood of the limbus.

An essential feature of phlyctenular inflammation is the early formation of leashes of blood-vessels running to or toward the infiltrated area. This is particularly marked in the so-called fascicular keratitis, in which a number of parallel blood-vessels, closely crowded together, lead to the phlyctenular ulcer;

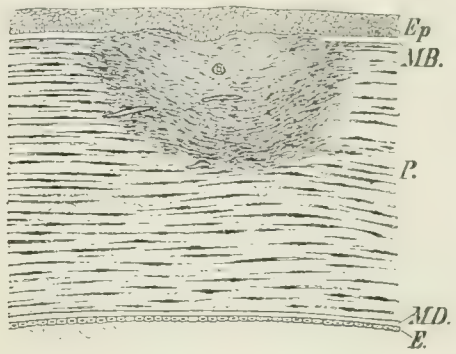



Fig. 1458.—Corneal Scar. *Ep*, Epithelium; *MB*, Bowman's membrane; *P*, substantia propria; *MD*, Descemet's membrane; *E*, endothelium of Descemet's membrane. (Elschnig.)

the latter as it heals being succeeded by another ulcer in advance of the first, to which the blood-vessels again proceed. The renewal of the ulcer may be several times repeated, the final healing leaving a band-like opacity. Sometimes phlyctenular keratitis appears as an irregular linear infiltration extending around a large part of the corneal limbus.

On account of its very frequent association with a general eczematous tendency, the disease has been widely spoken of, especially among the Germans, as eczematous keratitis. It is the commonest form of

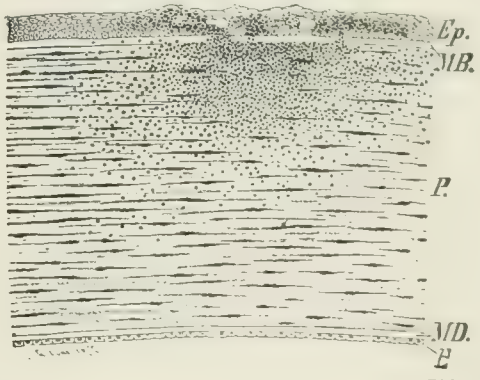



Fig. 1559.—Superficial Infiltration of the Cornea in Phlyctenular Keratitis. *Ep*, Epithelium; *MB*, Bowman's membrane; *P*, substantia propria; *MD*, Descemet's membrane; *E*, endothelium of Descemet's membrane. (Elschnig.)

corneal inflammation, and its incidence is almost limited to children, particularly between the ages of two and twelve years. Most of the patients have tonsillar or adenoid hypertrophy, with chronic rhinitis. De Schweinitz makes the rather sweeping statement that infectious rhinitis is a constantly associated disorder. There is an increasing tendency to regard phlyctenular inflammation as due to the presence of tuberculosis, although it is very doubtful whether, as some writers have contended, the tubercle bacilli are

the direct cause of the phlyctenules. A large percentage of all cases react positively to tuberculin tests. A very important influence is that of improper feeding. Many of the children are the subjects of perverted rather than inadequate nutrition; and attention to this one detail will frequently produce surprisingly rapid improvement.

In the milder cases the disease is of short duration and leaves little or no permanent disturbance. But on the other hand, there is a marked tendency to repetition of the disorder, and some of the cases may even be described as malignant. In these patients, the eye is almost constantly inflamed for a long period; never entirely well, though showing temporary improvement. In the result, the transparency and regularity of the cornea may be impaired to such an extent as to leave the patient incapable of reading ordinary type. Even single phlyctenules, if severe and centrally located, may greatly reduce the visual acuity.

*Symptoms.*—The most marked symptom of a case of phlyctenular keratitis is the photophobia, which is commonly more decided than in the conjunctival form, and is sometimes so extreme as to render the patient for all practical purposes blind. The child gropes its way around with the eyes tightly shut, or buries its head in the bed-clothes. In many cases there is more or less congestion of the whole conjunctiva. Lacrymation is very free. In some instances there is a mucopurulent discharge. Occasionally a single deep ulcer is formed, with a strong tendency to perforation.

In young children, a satisfactory examination of the eyes is often made difficult by the extreme photophobia. In such cases the preliminary instillation of a drop of cocaine may facilitate matters. It may further be necessary to take the child's head between the surgeon's knees, and to use a lid retractor.

*Treatment.*—The constant covering of the eyes with the bed-clothes or a handkerchief is injurious. Exposure to light and air as far as practicable is favorable to recovery. The sensitiveness of the eyes will be greatly diminished by instillation of a solution of atropine. Dark glasses should also be worn. Any facial eczema present should be thoroughly treated. If fissures exist at the outer canthus, they should be touched with a solution of silver nitrate, and the same may be done to ulcerations on the edges of the lids. Marked redness and thickening of the conjunctiva are to be treated by applying a solution of tannin in glycerin to the everted lids.

The most serviceable local application for the phlyctenular eruption is the salve of yellow oxide of mercury, usually in one per cent. strength. This should be introduced into the conjunctival sac once in twenty-four hours, preferably at bedtime, and distributed thoroughly by massage outside the closed lids. Or powdered calomel may be dusted over the cornea; provided, however, that no form of iodine is being given internally. If there is a mucopurulent discharge, the eyes should be frequently irrigated with a boric-acid solution.

Since the disease unquestionably rests on a constitutional basis, strict control of diet, mild purging especially with fractional doses of calomel, the use of general tonics, and attention to any irregularities in the nose and throat, are of great importance. In mild cases the local use of yellow oxide of mercury, with or without atropine, is often all that is required. In severe cases the most exhaustive study of the case may fail to yield satisfactory results. The influence of carious teeth on corneal disease should not be overlooked in obstinate cases.

Corneal Ulcer.—In books on the eye, the most varied classifications are adopted for the description of ulcers of the cornea. They are grouped according to the responsible organism, according to their shape, position, and progress, according to general diseases with which they are sometimes associated, and according to special characteristics. Yet no classification is scientifically satisfactory or therapeutically very serviceable. Every corneal ulcer presents an interruption in the normal continuity of surface. For every corneal ulcer the essential lines of treatment are similar. All corneal ulcers have much in common as regards the symptoms by which they are accompanied and the dangers involved.

Simple Ulcer.—The term "simple" is commonly applied to an ulcer without tendency to marked tissue destruction and surrounding infiltration, and which is not inclined to extend after it has once formed. Its base is often clean, but may be grayish. Its natural course is toward recovery, especially if the special underlying cause is removed. The latter may consist of an attack of herpes, or a phlyctenular eruption, or trauma of external origin or by a rough or deformed lid. In some simple ulcers, consisting merely of traumatic loss of substance, the pain is severe and lacrymation profuse. As in most corneal lesions

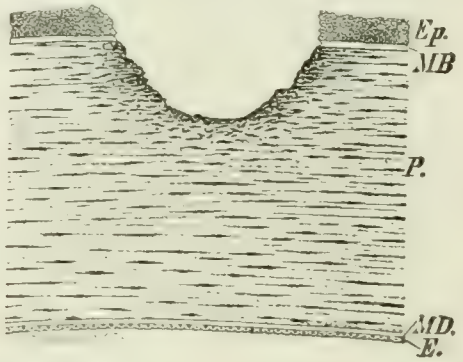



Fig. 1560.—Simple Ulcer of the Cornea. *Ep*, Epithelium; *MB*, Bowman's membrane; *P*, substantia propria; *MD*, Descemet's membrane; *E*, endothelium of Descemet's membrane. (Elschnig.)

there are also likely to be photophobia and more or less circumcorneal injection, consisting of a diffuse pinkish halo. If the ulcer is not fairly central, the congestion is likely to be most marked at the part of the limbus nearest to it. The depression becomes glazed over by the formation of new epithelium, before the gap in the underlying tissue has been filled in.

Treatment.—If simple ulcer is due to a foreign body which is still in the cornea, the offending particle must first be thoroughly removed, together with any stain which accompanies it. Beyond this, the treatment consists in the use of cleansing solutions, the instillation of atropine, or in some cases one of the briefer mydriatics such as duboisin or homatropine, and, in cases where the eye is exposed to infection, the wearing of a light protective dressing until the surface is covered with epithelium. Where traumatic abrasion is extensive, an excellent procedure is to fill the conjunctival sac with a bland antiseptic salve, and apply a protective dressing which is left in place for twenty-four hours. If pain is severe and persistent, hot applications will prove agreeable.

Suppurating Ulcer.—An infected or suppurating ulcer is one which tends to advance, with destruction of adjacent tissue. The great danger from such an ulcer is that of perforation of the cornea; but very serious diminution of vision may occur without rupture. The microorganisms most commonly concerned in suppurating corneal ulcer will be referred to under separate headings. The course of a suppurating ulcer depends very greatly upon the age and general resistance of the patient. The presence of chronic infection of the lacrymal passages has an extremely important bearing on the tendency of slight injuries

to the cornea to result in dangerous ulceration. A very large percentage of all eyes lost from corneal ulcer have previously been subject to chronic dacryocystitis. Even without this condition, a corneal ulcer occurring late in life is very liable to prove fatal to the eye.

The symptoms of suppurating ulcer are those of simple ulcer, only often in greater severity, especially as regards pain and congestion, the latter tending to involve the whole of the conjunctiva.

*Pneumococcus Ulcer.*—The pneumococcus of Fraenkel and Weichselbaum is the cause of a large percentage of the rapidly destructive suppurating ulcers of the cornea. On account of the rapid extension of these ulcers across the corneal tissue, the name serpent ulcer has been widely used for them. It is significant that the pneumococcus is the organism most frequently found in chronic dacryocystitis. The typical serpent ulcer commonly advances from one edge, toward which the floor of the ulcer slopes. The floor of the ulcer is irregular and covered by cellular débris. The advancing edge of the ulcer, or in some cases the whole margin, is undermined, and yellowish in color.

There is usually more or less hypopyon. This consists of a mass of leucocytes, with a greater or lesser admixture of fibrin, which, being thrown out from the vascular system of the iris as a part of the process of resistance to the corneal infection, gravitate to the bottom of the anterior chamber, and there appear as a crescentic yellowish mass. It does not contain bacteria, and does not represent an intraocular infection.

Pneumococcic ulcer advances by necrosis of the corneal lamellæ, probably produced by the albuminous toxins thrown off by the organism. Where the resistance is good or the infection less virulent, the ulcer may remain shallow and rather small. Where the opposite conditions prevail, the whole cornea may be destroyed in the course of a few days. The pain accompanying a pneumococcic ulcer is usually intense, and the patient suffers from loss of sleep. Perforation frequently occurs, and in a person of advanced years the resulting panophthalmitis may be accompanied by marked systemic depression which is only relieved by enucleation of the eye. Pneumococcic infection complicating the postoperative course of cataract extraction involves the whole thickness of the cornea. The disease is rare in children, approximately eighty-five per cent. of the cases being in patients over forty years of age.

The danger of perforation exists as long as the ulcer continues to advance, especially if the tendency to repair is slight or absent. The normal thickness of the cornea is about one millimeter, but some corneas are much thinner than this. Moreover, the deeper layers of the cornea, which often resist perforation for some time after the greater part of the corneal thickness has been destroyed, may bulge into the ulcer in such fashion as to make the ulcer appear shallower than it really is, so that perforation often occurs when it is not at all expected. On the other hand, swelling of the margins of the ulcer may enhance its apparent depth. When the cornea ruptures, the aqueous humor at once escapes. The pupil contracts, bringing the iris in front of the opening, unless the latter is central and very small. Once caught in the perforation, the iris adheres to its margins, bulges between them, and finally becomes firmly incorporated in the scar tissue by which the necrosed corneal tissue is replaced. If the opening is not covered by the iris, the lens is brought into contact with the cornea, and the anterior capsule undergoes proliferation. When the anterior chamber reforms, the exudate uniting the lens to the cornea is torn asunder, but that part of it which continues to adhere to the anterior capsule,

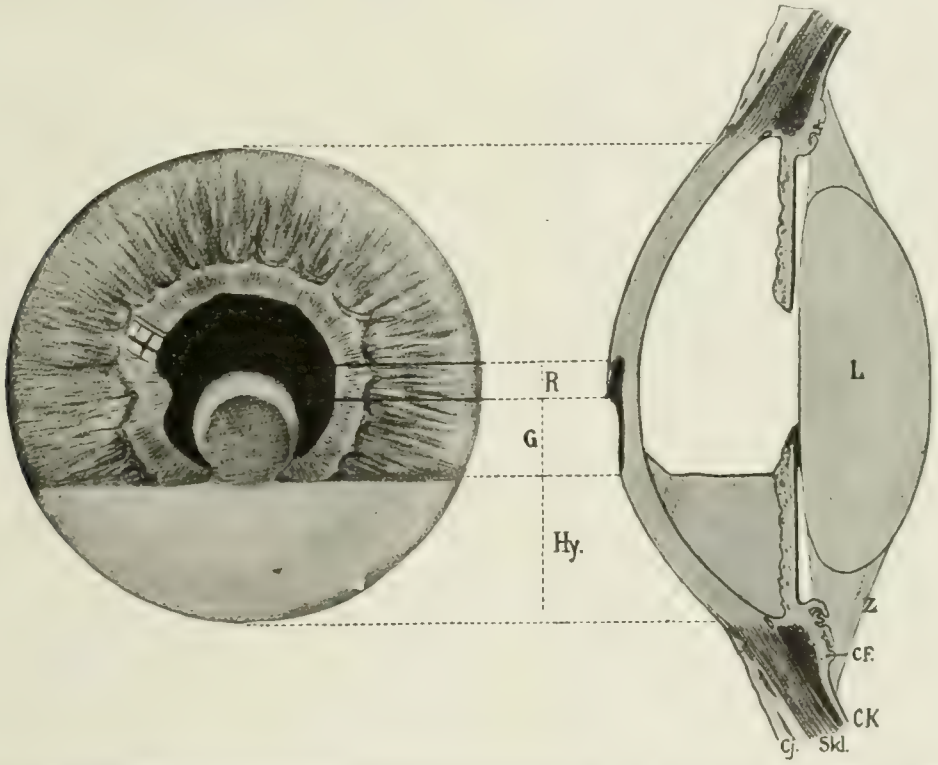



FIG. 1561.—Clinical Appearance and Anatomy of Serpent Ulcer of the Cornea. *Cj*, Conjunctiva; *Skl*, sclera; *CK*, ciliary body; *CF*, ciliary process; *Z*, zonule of Zinn; *L*, lens; *G*, ulcer; *R*, progressive margin of the ulcer; *Hy*, hypopyon. (Elschnig.)

together with the disturbance in the capsule, combine to form an anterior polar opacity.

Treatment.—The first essential in the treatment of serpent ulcer is, if possible, to remove the original cause. Inasmuch as fifty per cent. or more of some series of cases have been attributed to chronic dacryocystitis, the condition of the lacrymal sac should receive prompt attention. Vigorous cleansing and antisepsis of the sac, or its complete removal, may be the indispensable requirement for saving the affected eye. If the ulcer began as the result of an injury, any foreign material persisting in the cornea must be thoroughly removed. Poor systemic condition will call for the internal administration of tonics and stimulation.

In addition to careful cleansing of the conjunctival sac, it is decidedly advantageous to scrape the ulcer free from all loose material with a foreign body spud

Fig. 1562.—Hypopyon Keratitis. *A*, Abscess; *F*, $F_1$, $F_2$, $F_3$, fibrin; *H*, hypopyon; *P*, pus; *Sc*, Schlemm's canal; *U*, ulcer. (Green and Ewing, Trans. Am. Ophthalmological Society, 1896.)

or other blunt instrument. This process may be repeated every day if necessary. Cocaine must be instilled (preferably in four per cent. solution) before manipulation of the cornea is attempted. After the first curettage, a marked change for the better may often be obtained by touching the ulcer with strong nitric acid. This may be done by dipping a wooden toothpick in the pure acid, and then waiting until the acid has so far soaked into the wood that this appears practically dry before applying it to the cornea. Particular attention must be given to touching the margins of the ulcer, since it is mainly by these that spreading occurs. For a like purpose pure carbolic or glacial acetic acid, or the galvanic or actual cautery, may be used. Difficulty in applying the cautery arises rather from the sensation of heat due to the proximity of the needle to the eye than to actual pain from the cauterization. It is well to approach the eye quickly and withdraw with equal promptness after touching the affected area. The pain due to the ulcer is often much lessened after cauterization.

Several writers have recently urged the treatment of corneal ulcer by means of dry heat. This may be applied by holding a cautery electrode as close to the ulcer as the patient will bear, or by squirting heated air against the ulcer and the surrounding cornea from the "chip-blower" used by dentists. The latter has a rubber bulb and a metal nozzle, and the air is heated by drawing it into the bulb while the nozzle is held in a flame.

In most cases the pupil should be kept dilated as widely as possible by the use of atropine. Eserine is sometimes preferred to atropine in those cases where the ulcer is peripheral. Gunnufsen recently studied the tension of a series of cases of serpent ulcer by means of the Schiötz tonometer. He found that the prolonged use of atropine had the effect of increasing the tension, and that only among cases in which atropine was employed did dangerous rise of tension occur. Special steps are often required for the relief of pain. In the first place hot applications may be tried, either wet or dry. Where these are ineffectual, small doses of acetanilide, phenacetin, or aspirin may be beneficial. But in some instances it becomes necessary to resort to morphine. In this event, mild laxatives will be required to overcome the constipating effect of the narcotic. Serum therapy may be tried, but affords little prospect of relief. Some writers have reported marked improvement from the use of subconjunctival injections, either of salt solution in various strengths, or of the bichloride or other salts of mercury. The remedy is an heroic one, causing much pain and a violent reaction which often includes edema of the whole side of the face, and there is much difference of opinion as to its advantages. If the ulcer is accompanied by marked conjunctivitis, the everted lids may be brushed with a one per cent. solution of silver nitrate.

The improvement in the course of the ulcer following spontaneous perforation of the eyeball is often very striking. It is probably due to the relief of tension, which favors a greater lymph flow through the corneal tissue, and so hastens the natural processes of resistance and repair. This fact led to the therapeutic use of paracentesis of the anterior chamber. In the so-called Saemisch incision, this is done by passing a cataract knife through the cornea from sound tissue on one side of the ulcer to sound tissue on the other side, bisecting the ulcer. Or the anterior chamber may be drained by inserting a lance keratome or cataract knife near the periphery of the cornea, turning the knife in the wound to favor escape of the aqueous. Paracentesis is especially advisable if rupture of the ulcer appears imminent. It may be repeated, or the original incision may be reopened with a probe, from day to day if necessary.

Once the iris has prolapsed as the result of perforation of the cornea, the question of removing the protruding tissue must be decided. If the infiltration of the cornea is still marked, and the prolapse large, and especially if the prolapse has existed for twenty-four hours or more, it is usually well not to interfere. But if the prolapse is fresh, and the perforation small, and if the cornea is in fairly good condition, the protruding iris may be excised. After thorough cocainization, the hernia should be drawn upon with a pair of forceps so as to break up adhesions with the cornea as far as possible. Then with scissors the iris, still kept on the stretch, is cut off close to the cornea.

*Diplobacillary Ulcer.*—The diplobacillus of Morax and Axenfeld produces a variety of corneal lesions. It is sometimes the etiological agent of serpent ulcer such as has just been described. Other corneal lesions

resulting from this organism are shallow ulcers producing but little corneal infiltration, a superficial marginal ulcer, and a marginal infiltration without definite ulcer. In every case, corneal lesions produced by the diplobacillus are accompanied by conjunctivitis, and the less significant corneal disturbances in which this germ is a factor are probably always secondary to a diplobacillus conjunctivitis.

*Streptococcus Ulcer.*—An extremely dangerous corneal ulcer of the serpent variety is occasionally produced by the streptococcus. Its course is even more rapid than that of pneumococcus ulcer.

*Bacillus Pyocyaneus Ulcer.*—In a few instances this organism has been demonstrated to be the cause of corneal ulcer. In all the well reported cases, the infection was secondary to injury. The discharge, and the necrotic tissue lying in the ulcer, have the characteristic greenish-yellow color associated with this bacillus. Ophthalmitis is extremely likely to result in these cases.

*Other Organisms.*—Corneal ulcer with hypopyon may also be due to the staphylococci, the colon bacillus, *B. subtilis*, and the pneumobacillus of Friedländer.

*Mooren's (or Rodent) Ulcer.*—This rare ulcer was first described by Bowman in 1849, and again by Mooren in 1867. It runs a chronic course, lasting anywhere from several months to years. It begins near the upper or lower margin of the cornea, or in both situations, and progresses toward the center of the cornea, the ulcer proper being separated from the periphery of the cornea by a deeply undermined border. Bowman's membrane and the outer third or more of the cornea undergo necrosis, and in time the whole corneal surface is usually involved. Perforation does not occur, but very little vision is obtained through the scar tissue. The ulcer occurs in adults whose general nutrition is much depressed, and no treatment offers much prospect of relief.

*Ring Abscess of the Cornea.*—Fuchs, and later Morax and Hanke, have described a peculiar infiltration of the cornea arising after perforating injury, either accidental or from operation. The ring is concentric with the corneal margin, and develops rapidly. After a few days the whole cornea becomes involved and sloughs, and panophthalmitis usually follows. Fuchs reports recovery of one case after cauterization of the wound.

*Aspergillus Ulcer.*—A well-defined form of corneal ulcer may be produced by aspergillus fumigatus, aspergillus flavus, or aspergillus niger. The ulcer may be of a severe type, accompanied by hypopyon, with extensive destruction of corneal tissue; but more commonly the general manifestations are relatively mild. In either case the ulcer consists of a dirty yellowish patch, slightly raised at the periphery, but separated from the surrounding cornea by a delicate groove. The adjacent cornea is infiltrated, and blood-vessels may extend from the limbus to the diseased area, somewhat after the fashion of a phlyctenular inflammation. The fungus is always introduced with a foreign body, such as a splinter of wood, or a sharp vegetable fragment; and an incubation period of from several days to a week or two elapses before the ulcer develops. The symptoms are much the same as those of corneal injury. There is a good deal of burning and lacrymation, and in the rarer severe cases the discharge is abundant. The branching mycelium is readily found on examining the necrotic tissue under the low power of the microscope. The treatment consists of thorough curettage of the diseased patch, and light cauterization of the bed of the ulcer.

*Marginal Ulcer.*—In addition to the marginal variety of phlyctenular conjunctivitis, this term is applied to a narrow crescentic ulcer which extends for some distance along the limbus, and occasionally the whole way around the cornea.

*Variolous Ulcer of the Cornea.*—In very rare, malignant cases the cornea shares in the general eruption of smallpox pustules. Such cases of the disease are generally fatal. In the convalescent stage of smallpox, the cornea is sometimes the seat of a suppurating ulcer of considerable severity.

Abscess of the Cornea.—This condition is distinct from both hypopyon and corneal ulcer, in that it consists of a collection of pus cells between the intact corneal layers. It is usually secondary either to traumatism or to infection in other parts of the eye. The symptoms, which are usually very severe, including at times conjunctival chemosis and swelling of the lids, closely resemble those of corneal ulcer. They increase in intensity until rupture occurs. This is usually toward the surface of the cornea. The subsequent course is that of a suppurating ulcer.

Malarial Ulcer.—Patients who have had malaria are rather frequently affected by a form of corneal ulcer which is apparently of a specific character. Local treatment of these ulcers is ineffectual unless combined with the systemic treatment proper to the disease, that is, the administration of quinine. Although the infiltration is usually not marked, pain and pericorneal redness are commonly severe. The ulcer has a branching shape. The affected region of the cornea is often insensitive to the touch.

Dendritic Ulcer.—This rather rare affection has some similarity to malarial ulcer. It is apparently due to a disturbance in the nerves of the cornea. Commencing usually near the periphery of the cornea, it appears first as a line of infiltration, slightly raised above the general surface. In time the corneal epithelium breaks down along this line, and a grooved ulcer is formed. To this are added delicate branching lines of infiltration which follow the same course as the first. The affected region of the cornea is insensitive to touch, although the eye is as a rule quite painful, the sensation and reaction resembling those produced by a foreign body in the cornea. In some cases the course of the disease is very sluggish and the symptoms slight. Relapses are common, and opacities are left corresponding to the position of the grooves.

While the cause of the disease is unknown, any systemic condition likely to result in neuropathic disturbances should be investigated and treated. Antirheumatics such as the salicylates and aspirin may be of service. Locally curettage and cauterization of the grooves, hot fomentations, and sometimes the use of atropine, are likely to be of benefit.

*Treatment of Corneal Opacity Resulting from Ulceration.*—Opinions differ as to how far absorption of corneal scar tissue may be hastened or increased by artificial means. Most scars tend spontaneously to become somewhat less opaque in course of time; and this is particularly true of those acquired in early life. A favorite method for stimulation of absorption is by massage through the closed lids, after the introduction into the conjunctival sac of a small amount of one per cent. yellow oxide of mercury salve. The reaction produced by dionin, either dry or in solutions of various strength, has been found beneficial by some workers, while others favor the use of salt solution or other preparation in subconjunctival injection. The internal administration of thiosinamin has been recommended, but its efficacy is questionable. Vibratory massage through the closed lids has also been suggested. Optical iridectomy may greatly improve the patient's vision. Tattooing is done for cosmetic purposes, but has sometimes been accused of producing chronic irritation.

Many unsuccessful attempts have been made to replace opaque corneal tissue by transplantation of grafts from animal eyes. The most important cause of failure seems to be the incompatibility between tissues derived from different species. Thus grafts transplanted from the rabbit's cornea on to human

eyes become disintegrated by antibodies from the serum of the human patient. Recently, Magitot has found that by repeated washing of corneal tissue with Locke's solution, and subsequent preservation in hemolyzed blood serum of the species of animal from which the corneal tissue was taken, at a temperature of from 5 to 8° C., such tissue can be kept alive for more than two weeks. Such tissue can be grafted on to the cornea of an animal of the same species. The graft retains its transparency, and the irregular astigmatism at first present subsequently diminishes. Magitot suggests the preservation by his method of the corneas of still-born children, for transplantation on to leucomatous eyes.

Herpes of the Cornea.—Herpetic eruptions on the cornea are described by the various authors under the headings of febrile and neuralgic herpes, and herpes zoster. The first two conditions are similar, and consist of the development of clusters of vesicles in association with or subsequent to a similar eruption on adjacent parts of the face, within the distribution of the fifth nerve. The tiny blisters rupture, leaving shallow depressions, usually without appreciable infiltration of the surrounding cornea. Permanent opacity at the site of the vesicles commonly results. The development of the vesicles and ulcers is accompanied by sharp pains, increased lacrymation, and sometimes a mucopurulent discharge. Of a total of 235 cases of herpes zoster collected by Wilbrand and Saenger, the cornea was affected in eighty-three. The severity of the disease varies considerably. Herpes zoster runs a characteristically slow and obstinate course, successive crops of vesicles often apearing in different parts of the cornea.

The *treatment* consists of cleansing the conjunctival sac with mild antiseptic solutions, boric acid solution for instance; and the instillation in severe cases, or where iritis develops, of a one per cent. solution of atropine, once daily. Internally the course of the disease may be somewhat shortened and pain relieved by the liberal administration of salicylate of sodium or quinine. Repeated use of cocaine in the eye is undesirable, but a weak solution (one per cent.) of holocaine is unobjectionable. Hot applications and dionin are also recommended.

Keratitis. *Neuroparalytic Keratitis.*—Wilbrand and Saenger regard neuroparalytic keratitis as closely related to herpes of the cornea, and due to disease affecting the trigeminus, in any part of its course. It is a complication to be guarded against after surgical removal of the Gasserian ganglion for facial neuralgia. When this operation has been performed, the eye should for some weeks be kept closed and protected by an occlusive bandage. The cornea is usually insensitive. According to one theory the corneal lesions arise because the cornea is no longer protected by its sensibility against foreign bodies, undue exposure, and lack of moisture. Another line of reasoning regards the keratitis as trophic in character. Secondary infection occurs in many cases. The symptoms of the simple paralytic condition are not usually severe and if the deeper structures are not involved the patient may experience no pain. The local treatment resembles that of corneal herpes, a protective dressing being called for during the night. During the day the risks attending exposure may be avoided by the introduction of a mild antiseptic salve into the conjunctival sac at frequent intervals. The prognosis is bad where the nerve lesions underlying the local disease persist; although with proper care cases due to extirpation of the Gasserian ganglion commonly recover.

*Bullous Keratitis.*—This condition arises in corneas whose nutrition has been interfered with by chronic glaucoma, iridocyclitis, or traumatism. A blister forms which is filled with fluid lying between Bowman's membrane and the epithelial layer of the cornea. Recovery may occur after simple puncture of the blebs, or scraping and cauterization may be necessary. When the eye is blind and subject to recurrent attacks of bullous keratitis, enucleation becomes advisable.

*Filamentous Keratitis.*—This condition may be secondary to corneal traumatism, or may arise without apparent cause. In either case the essential feature is the appearance of twisted filaments, attached to the cornea, and composed of corneal epithelium. In the idiopathic cases the formation of the filaments is preceded by the development of vesicles, which rupture, the epithelium remaining attached at one point. The process is similar in some of the traumatic cases; but in these apparent healing of the original wound has usually occurred before the vesicles form. The symptoms are those of foreign body in the cornea, or of epithelial abrasion. The condition is sometimes rather obstinate, in which event the most effective method of treatment is usually to curette and afterward cauterize the affected surface.

*Relapsing Traumatic Keratitis.*—This condition is allied to the one just mentioned. Some time after the cornea has been superficially wounded—usually by an abrasion of the epithelium—the patient experiences the sensations associated with the presence of a foreign body in the cornea, and the site of the original injury presents a minute vesicle, intact or ruptured, or a small erosion of the epithelial surface. The phenomenon may recur at intervals over a prolonged period. The treatment is that of corneal ulcer, with curettage and cauterization if necessary.

*Disciform Keratitis.*—Under this title Fuchs describes a more or less circular and approximately central opacity of the cornea, developing slowly in the parenchyma. The central opacity sometimes contains points of dense opacity, and is surrounded by one or more rings of slighter disturbance. The symptoms are not always marked, although iridocyclitis may develop. There is sometimes slight vascularity of the cornea. The epithelial surface over the opacity is dull, and lacks sensibility. The etiology is unknown. The disease lasts for several months and commonly leaves a fairly considerable permanent opacity. Treatment has little effect. Weeks believes he has seen good results follow the use of hot fomentations, dionin, and atropine.

*Punctate Keratitis.*—Deep punctate keratitis is merely a symptom of inflammation involving the uveal tract. It consists of numerous small punctate opacities on the posterior surface of the cornea, usually grouped in a more or less triangular arrangement below the center of the cornea. As superficial punctate keratitis is described a condition possibly related to corneal herpes, and characterized by the appearance of minute dots scattered over the epithelial surface.

*Desiccation Keratitis.*—The normal condition of the cornea can be maintained only so long as it is regularly moistened by the lacrymal secretion. If the epithelium remains dry and exposed for a lengthy period, its nutrition is interfered with and it offers a favorable lodgment for bacteria. Conditions favorable to desiccation keratitis are found whenever the lids fail to blink shut during prolonged depressing illness; when they remain open during sleep or at other times as the result of paralysis of the orbicularis muscle; in retraction of the lids by contraction of scar tissue from burns, disease, or other injuries of the face; or in exophthalmus from any cause. Inasmuch as the symptoms are often slight at first, the cornea should be carefully watched in any case where continued exposure is likely to occur. The remedy may consist of plastic operations (in the case of cicatricial ectropion), of a protective bandage, or of stitching the lids together until such time as the cause of the exposure no longer exists. The final outcome is not infrequently a destructive panophthalmitis.

*Sclerosing or Sclerotizing Keratitis.*—This is an

opacity of the deeper layers of the cornea which sometimes develops in connection with an inflammation of the sclera. It is continuous with the affected region of the sclera, and its shape is triangular with the base at the corneal margin.

*Keratitis Marginalis Profunda.*—This is the name given by Fuchs to a rare form of corneal inflammation, in which a zone of opacity advances from the sclera into the corneal substance. About a half of the corneal circumference is involved, the inflammatory symptoms are severe, and the opacity is covered by blood-vessels. After the inflammation subsides, an infiltrated crescent remains, somewhat resembling arcus senilis, but differing from it in that there is no clear space between the sclera and the corneal opacity. Ulceration does not occur.

Keratomalacia.—This is a rapid sloughing of the cornea, accompanied by but little reaction, which occurs rarely in marasmic infants and in the last stages of exhausting diseases. Treatment is useless, except so far as it reaches the general condition of the patient. In the infantile form both corneas are usually affected.

Band-shaped Degeneration of the Cornea.—In eyes which have been blind for a long time from inflammations of the uveal tract, panophthalmitis, or sympathetic inflammation, especially where rupture of the cornea and extensive leucoma have occurred, the opaque corneal tissue not infrequently undergoes a late degeneration which leads finally to the deposition of lime salts in the substantia propria and the coats external to it. The degeneration generally appears first in the form of fat-like globules composed of a hyaline substance, the calcareous changes occurring later. The degenerated area often takes the form of a band lying transversely across the cornea below its center, opposite the palpebral fissure.

A somewhat similar condition occasionally develops in the previously healthy eyes of the aged. It is then bilateral, develops very slowly, and is only occasionally associated with sluggish inflammatory disease of the iris or retina, or with glaucoma.

If the fundus of the eye is believed to be still in a satisfactory condition, the patient's sight may be improved by curetting the degenerated surface. After this has been done further gain may be hoped for from the stimulating effect of hot applications.

Arcus Senilis.—A true arcus senilis, or gerontoxon, is always separated from the neighboring sclera by a narrow margin of clear cornea. It consists of a fatty degeneration of the substantia propria. Its presence in no way affects the prognosis as regards healing of operative corneal wounds, as in cataract extraction. A somewhat similar opacity is very rarely seen in early life.

Blood Staining of the Cornea.—This condition is very rare, and arises after the presence of blood in the anterior chamber of an eye whose tension is abnormally high. According to Collins and de Schweinitz, who have studied cases, the stain takes at least two years to disappear entirely.

Chemical Deposits in the Cornea.—After lime burns, the albuminate of lime remains embedded in the corneal tissue. Guillery treated this condition by bathing the eye with ammonium chloride. Deposits of carbonate of lead may follow the use of a collyrium of acetate of lead for the treatment of corneal ulcer. Inasmuch as the deposit is more or less superficial, the most satisfactory treatment is to scrape out or excise the affected tissue. A brown deposit of oxide of silver may result from the use of nitrate of silver in cases of corneal ulceration. Such an accident, however, is rare, and it is doubtful whether the risk of its occurrence should be allowed to prevent the benefit that often results from the application of silver nitrate to the lids in some combined disturbances of the conjunctiva and cornea.

Corneal Opacities.—*Family Degeneration of the Cornea.*—This is an hereditary condition, and may also occur in several members of the same family. The opacity usually develops between the period of adolescence and the thirtieth year of life. As described by Fehr, the opacity is made up of little light gray streaks and dots. Both eyes are always affected and the vision becomes greatly reduced.

*Congenital Corneal Opacity* may also arise from intrauterine inflammations, or from arrest of the normal process of clearing of the embryonic corneal tissue.

*Striate Opacity of the Cornea.*—This condition is wrongly entitled striate keratitis, as it is not an inflammatory condition. It occurs sometimes after incised wounds of the cornea, and is seen with the corneal loupe as a series of delicate lines extending at right angles to the line of incision. The appearance is probably due to a rucking of Descemet's membrane, and is followed by no untoward results.

*Other Corneal Opacities.*—A variety of peculiar corneal disturbances, of unknown etiology, have from time to time been described by different authors. One is the "grill-like opacity" of Biber, Haab, and Freund, an hereditary disease appearing after the age of puberty, and consisting of a diffuse corneal opacity which appears under magnification as a grill-like network chiefly occupying the center of the cornea. Others are the nodular or guttate opacities of Groenouw and Fuchs; the keratitis profunda of Fuchs, characterized by the formation of a grayish stippled opacity situated in the deep layers of the cornea; and superficial punctate keratitis, a punctiform disturbance whose true character is probably better indicated by its synonym "relapsing herpes of the cornea."

Protrusions of the Cornea.—Protrusions of the cornea may be secondary to corneal inflammation, or may depend on an abnormal weakness and stretching of the corneal structures of unknown etiology. When a corneal ulcer perforates, the iris is usually drawn between the lips of the wound. As the perforation heals, the iris forms part of the tissue by which the defect is bridged over. That part of the iris which lies in the scar is transformed into new connective tissue. A part of the iris lying within the anterior chamber is held by the scar in close contact with the posterior surface of the cornea. Two results are likely to follow. In the first place the scar is weaker, and yields more readily to pressure, than the normal cornea. In the second place, the adhesion of the iris to the cornea interferes with the proper drainage of the intraocular fluids at the angle of the anterior chamber. The intraocular tension is thus increased, and the scar tissue gradually yields to the strain put upon it, and stretches. The bulging thus produced may remain localized, or may gradually involve the neighboring cornea, extending until the whole cornea protrudes. Localized and general bulging are known respectively as partial and complete *staphyloma*. So-called racemose staphyloma exists when protrusion is localized and multiple.

Fig. 1563.—Corneal Staphyloma, natural size. (After Saemisch.) *a*, Cicatricial tissue; *b*, crystalline lens.

In addition to the opacity existing at the site of the original scar tissue, the rest of the cornea tends in time to become opaque and white. So long as the cornea is in large part fairly transparent, the iris showing through it gives a bluish-gray color to the protrusion; from this the title staphyloma was originally derived, on account of supposed resemblance to a grape. Even if the staphyloma is localized and the rest of the cornea clear, its surface is usually

so irregular that visual acuity is poor. Completely staphylomatous eyes seldom have more than light perception. In many cases, especially where the staphyloma has developed at an early age, this remnant of vision is retained for years. But such eyes usually become completely blind sooner or later. They are subject to attacks of uveal inflammation, and are seldom completely quiet. The retina may be destroyed by the continued high tension. Or the cornea may rupture, perhaps repeatedly, until shrinking occurs, and a phthisic bulb results; or enucleation may be necessary on account of pain or disfigurement. Where the protrusion is large, it is easily seen or felt beneath the closed lids; or the size of the eyeball may so greatly increase that the lids cannot be approximated. The corneal distention may extend to the sclera, so that the whole eyeball is expanded. The development of "band-shaped opacity" in staphylomatous eyes has been discussed under that title.

In eyes whose corneas are partially staphylomatous, if the other eye has good vision no operative step should usually be undertaken. But if neither eye has useful vision, considerable improvement may sometimes be obtained by iridectomy. This should be small if the optical effect only is desired. But if the tension is abnormally high, the section removed should include the root of the iris, so as to establish, if possible, better intraocular drainage. Eyes with complete staphyloma are usually better left alone. Apart from the staphyloma they are not sound eyes, and operation may leave the last state of the patient worse than the first. However, if the distention is so great as to threaten spontaneous rupture, temporary relief may be obtained from paracentesis or from excision of a part or even the whole of the staphyloma. Since the introduction of anterior sclerocorneal trephining for glaucoma, the use of the same operation to reduce the tension of staphylomatous eyes has been suggested and tried, in some cases apparently with excellent results. The simplicity of the operation renders it less likely than some others to make the condition of the eye worse rather than better. Tattooing of the cornea is sometimes done to imitate the natural colors of the iris and pupil. Many cases come to enucleation or evisceration of the eyeball.

*Keratectasia* is the term applied to a local bulging of the cornea, resulting from the destruction of some of the corneal layers by disease, without actual perforation. A hernia of Descemet's membrane, protruding through the base of an ulcer, is known as a *keratocele*. It is usually only a preliminary to actual rupture of the ulcer.

*Keratoconus, conical cornea*, is a bulging of the cornea usually occurring before the age of twenty. It probably arises from abnormal weakness and inability of the corneal tissue to resist the normal intraocular tension, and frequently seems to originate from an exhausting febrile disease or some other condition which profoundly depresses the general strength of the patient. The apex of the cone commonly lies just below the center of the cornea, and its extreme point may present more or less definite opacity. In extent the condition varies from such slight conicity that the patient has excellent vision with the correcting lens, to protrusions of a half inch or more. It is usually bilateral, but one eye is as a rule much worse than the other. The lesion is more likely to be progressive if the eyes are used habitually under improper conditions, but sooner or later becomes stationary.

In pronounced cases the vision with any lens is unsatisfactory. The patient sees through the slope of the cone, and hence commonly has high myopic astigmatism, although with a fairly large pupil the peripheral refraction may be hyperopic. The lens accepted may vary greatly with different strengths of illumination, because different parts of the pupil are used. In refracting these cases, however, it must be remembered that the pupil contracts with convergence and accommodation. Attempts are sometimes made to reduce or check the keratoconus by galvanocauterization of the apex, or excision of a small piece of tissue at the same place. The use of a weak eserine solution once daily may improve vision by keeping the pupil small; and in some cases seems at the same time to diminish the tendency of the protrusion to increase.

*Keratoglobus.*—This expression is often used as synonymous with buphthalmus (see next paragraph). It is however sometimes applied to a stretching of the cornea allied to keratoconus, but in which the whole cornea is affected, the distention being irregularly globular. The eye appears prominent, the cornea is enlarged laterally, and the anterior chamber is deeper than normal. The only treatment called for is correction of the refractive error.

Buphthalmus.—This condition is also known as congenital glaucoma, hydrophthalmus, keratoglobus, and megalocornea. There is a general stretching of the coats of the whole eyeball, due to increased intraocular tension. The original cause of this is disputed. It is probable that there are two classes of cases, one depending on failure of the normal development of the drainage channels at the angle of the anterior chamber, the other resulting from ocular inflammation *in utero* with secondary blocking of the drainage channels. The cornea bulges, and the distended sclera has a bluish appearance due to its thinness. The optic disc becomes cupped just as in adult glaucoma, and the nerve elements of the retina are more or less damaged by pressure. Vision is often altogether lost. Both eyes are commonly affected. Benefit is sometimes derived from the instillation of eserine, or from an iridectomy. Anterior scleral trephining may also be considered.

Parenchymatous Keratitis.—The name "parenchymatous" or "interstitial keratitis" may be correctly applied to any inflammation occurring in the corneal substance, without tendency to suppuration or ulceration, but accompanied by more or less vascularization of the corneal tissue.

*Symptoms* of irritation are usually present in marked degree, although cases have been observed in which loss of vision was the first or only symptom complained of. In most cases the early symptoms include photophobia and lacrymation, with disturbance of vision. There is a zone of pericorneal redness. The development of opacity in the substantia propria of the cornea usually proceeds from the periphery and gradually advances toward the center, but the center of the cornea is sometimes first involved. From the enlarged superficial vessels surrounding the limbus, a number of short parallel branches advance on to the cornea, their ends usually lying in a fairly regular line with one another. The opacity is seldom equally dense throughout, and may consist of more or less independent areas of denser infiltration, with intervening areas of hazy or even clear corneal tissue.

As the subjective symptoms become more severe, blood-vessels grow from the limbus into the opaque areas, producing a dull red appearance of the cornea which has given rise to the descriptive term "salmon patch." The whole cornea may be involved, and the vision reduced to light perception. The infiltration may become so dense as to have the appearance of an abscess. Occasionally ulceration occurs.

After a period varying from weeks to months, the symptoms slowly subside and clearing of the cornea begins, improvement more frequently occurring first in the parts which were first involved. Some permanent opacity is almost always left, although after recovery the cornea frequently appears clear until studied by lateral illumination. Unevenness of surface of the clear cornea produces a good deal of

irregular astigmatism. In some cases a few of the interstitial blood-vessels may persist for months or years after the inflammation has subsided; although magnification and oblique illumination may be necessary to reveal them. In cases due to hereditary syphilis, the second eye usually becomes involved some time after the first. The iris and the rest of the uveal tract are affected in the majority of instances.

*Etiology.*—The disease occurs most frequently between the ages of five and fifteen years, although it has been observed as late as the end of the fifth decade. In the great majority of cases it appears in the subjects of hereditary syphilis, and these cases are almost always bilateral. In the small percentage of cases due to acquired syphilis, the disease is more commonly unilateral. The diagnosis of the disease as due to syphilis is facilitated by the various stigmata of hereditary lues, including saddle nose, rhagades at the angles of the mouth, and the peculiar separated, peg-shaped, and notched incisor teeth to which Hutchinson's name is classically applied. An important percentage of cases of interstitial keratitis is tuberculous in origin. Other factors include rheumatism, rickets, and malaria. A few cases are probably related to dental caries.

*Treatment.*—Since so large a proportion of cases of parenchymatous keratitis is due to syphilis, and so considerable a minority to tuberculosis, it might be supposed *a priori* that systemic measures would be of great value. Unfortunately, as regards syphilitic cases this is seldom the fact. From time to time cases are recorded in which general antisyphilitic treatment has been followed by marked improvement in the condition of the eyes, and in the tuberculous cases tuberculin seems to have a definite value. But since the duration and severity of the disease vary so widely, the exact part played by therapeutic agents is hard to determine. Where the etiology is in doubt, Wassermann and tuberculin tests should be made, and the presence of either syphilis or tuberculosis appropriately dealt with. Mercury is most satisfactorily administered to children in the form of calomel, which may be given as an average to the extent of one-tenth grain three or four times daily. The results from Ehrlich's salvarsan or "606" in interstitial keratitis have been disappointing, although some observers have reported favorably.

Whatever other local treatment is used, atropine should be instilled daily as long as signs of irritation continue. Dark or amber glasses should be ordered on account of the photophobia. The most successful means of obtaining relief from the pain, as well as an excellent form of local stimulation, is often the application of heat, either dry or moist. Natural or artificial leeches to the temple are sometimes recommended for the relief of extreme hyperemia. Other forms of local treatment are of doubtful value in the active stage of the disease. Dusting the cornea with powdered calomel has been advised, but must be particularly avoided if the iodides are being used internally, on account of local incompatibility. When acute inflammation is past, absorption of infiltrates is possibly hastened by introducing one per cent. ointment of yellow oxide of mercury into the conjunctival sac, and massaging the eyeball through the closed lids. Dionin, in powder, ointment, or solution (preferably a two per cent. solution used once daily) may also serve to promote absorption. The general nutrition and strength of the patient must be given close attention, especially in the cases due to congenital syphilis.

Deep Vascular Keratitis (Salmon Patch).—Weeks describes separately under this head a limited vascular opacity of the cornea which occurs rarely in syphilitic subjects. It involves the deep layers of the substantia propria, affects a rather limited and well-defined area of the corneal periphery, and produces moderate symptoms of irritation. It may last several months. The treatment is similar to that of ordinary parenchymatous keratitis.

Tuberculosis of the Cornea.—This is most frequently due to extension from the uveal tract. It may, however, occur as a parenchymatous keratitis developing in an eye which was apparently previously healthy. Tuberculous parenchymatous keratitis commonly gives rise to less marked irritative symptoms than the syphilitic variety, and tends to appear as a number of yellowish deposits in the cornea, which have been compared to globules of mutton fat. The disease may also assume a nodular form, from the formation of distinct tubercles. In treatment, tuberculin in minute and cautiously increasing doses should be employed.

Pannus.—The condition known as pannus is an extensive vascular opacity involving the superficial layers of the cornea. The term is more particularly applied to trachomatous cases. In these the disturbance characteristically begins at the upper margin of the cornea, and ends below in a more or less regular horizontal line. Less extensive vascularity may start from the lower edge of the cornea, and in very severe cases the two invasions may meet, the whole cornea thus becoming involved. Pannus tenuis means thin pannus, whereas pannus crassus is a thick fleshy opacity. The expression pannus is less frequently applied to a marked chronic vascularity of the cornea, less regular than the trachomatous form, and occurring in aggravated and persistent cases of phlyctenular keratitis.

The nature of trachomatous pannus has been explained in two different ways. According to one view, the corneal changes are of purely mechanical origin, being due to irritation of the corneal epithelium produced by contact with the roughened conjunctival surface of the lids. It is true that the worst cases of pannus are more frequently seen in old cases of trachoma in which there is considerable scarring and deformity of the lids. But in the active stage of the conjunctival disease, cases of otherwise equal severity differ greatly as to the amount of corneal disturbance. The second view, and one well supported by microscopic study, regards trachomatous pannus as a specific invasion of the cornea by the same disease process as produced the changes in the conjunctiva. True lymph follicles, although modified in form, have apparently been demonstrated in the superficial layers of the cornea. The early changes consist of a vascular infiltration between the epithelium and Bowman's membrane. In severe cases, however, the disease extends through and beneath Bowman's membrane, which may be largely destroyed. Pannus is sometimes accompanied by ulceration of the cornea.

The treatment of pannus is almost entirely that of the conjunctival trachoma. As the condition of the lids improves, so the cornea becomes clearer, except so far as secondary lid deformities tend to keep up corneal irritation. After recovery, the cornea may become entirely transparent; but there is likely to be a good deal of irregularity of the epithelial surface, and vision is permanently more or less damaged. Distressing symptoms may be alleviated by the use of atropine and by the application of heat. If the corneal disturbance is unusually persistent after the conjunctival condition is improved, the blood-vessels which run to the pannus from the conjunctiva may be destroyed by the galvanocautery, or by the operation of peritomy. This consists in removing a narrow strip of conjunctiva at a short distance from the cornea. The strip may run all the way round the cornea, or may merely extend a little beyond the vascular region in each direction. Where the pannus is aggravated by deformity of the lids, and the palpebral fissure is contracted, canthotomy should be

done. This consists in a simple division of all the tissues for a short distance from the external canthus in a horizontal direction.

Injuries of the Cornea.—The cornea may become temporarily cloudy from contusion. It is more frequently subjected to abrasion, as by a finger nail or from a glancing blow by a foreign body. The symptoms following such an injury are pericorneal injection, lacrimation, photophobia, and pain. In the presence of chronic disease of the tear sac, such abraded wounds are very dangerous, especially in later life, and fatal ulcer may result. Otherwise a mere abrasion tends usually to heal promptly, the denuded surface being rapidly covered by epithelium. On account of the risk of infection the eye should be watched carefully until healing has occurred. Especially if the eye is much exposed to dust, a protective dressing should be used for short time, a small quantity of mild antiseptic salve having previously been placed in the conjunctival sac. The cornea is more

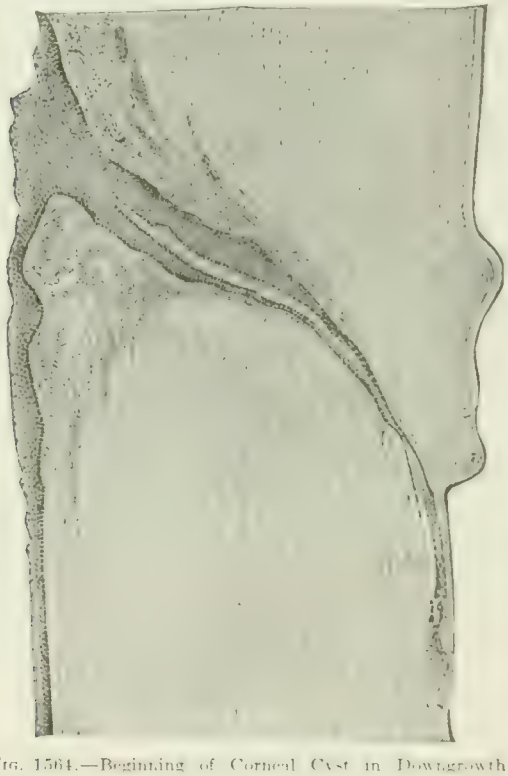


Fig. 1564.—Beginning of Corneal Cyst in Downgrowth of Epithelium into the Anterior Chamber Following an Incised Wound of the Cornea. (After Urmetzer in Græfe's Archiv.)

frequently injured by small foreign bodies becoming lodged in it, such as minute particles from an emery wheel, or tiny cinders. These should be thoroughly removed after instillation of four per cent. cocaine solution, the operation being preferably performed under good lateral illumination. Any stain left by the foreign body in the surrounding tissue should also be carefully scraped away, otherwise the irritation is likely to continue. Injury by lodgment of foreign bodies may give rise to dangerous ulcers, hence such cases must be kept under close observation until recovery.

Penetrating wounds of the cornea are most important on account of the risk of intraocular inflammation, although some opacity is always left at the site of injury. Such wounds seldom require suturing. When extensive, De Wecker and others favor covering them with a conjunctival flap, which is loosened from the sclera and secured by conjunctival sutures in such a way as to overlie the wound. Any protruding iris must be excised; the eye placed under the influence of atropine; and every possible step taken to favor asepsis, such as washing out the conjunctival sac, introducing an antiseptic salve inside the lids, and covering the closed lids with a light protective bandage. After any wound which lays the cornea open, the risk of sympathetic involvement of the other eye from chronic inflammation in the first eye must be carefully borne in mind. Penetrating wounds of the cornea are the most frequent cause of cysts lying back of the cornea in the anterior chamber.

*Burns and Scalds.*—Chemical burns of the cornea may be due to either acids or alkalies. In the former event the destruction is seldom deep and there is commonly little or no permanent damage to the eye. Burns by alkali are deeper in their effect. The most frequent alkali burn of the cornea is from lime. The particles are frequently propelled with considerable force, and hence become buried in the tissues, where their action is kept up for some time. Adhesions between the cornea and conjunctiva frequently result. The treatment is that given under Burns of the Conjunctiva (page 254). Some of the particle may call for instrumental removal.

The cornea may also be burned by molten metal (such as splashes of solder), or by steam, hot cinders, or gunpowder. Steam is likely to destroy a narrow strip of epithelium corresponding to the palpebral fissure. Splashes of solder do not usually cause serious injury, the eye being probably protected by the formation of a thin layer of steam between the cornea and the hot metal. The necrotic tissue surrounding heated foreign bodies such as cinders must be thrown off before healing occurs. The treatment consists in cleansing, removal of embedded foreign bodies or stains, and where extensive burn has resulted the subsequent frequent use of an oily preparation.

Tumors of the Cornea.—New growths starting in the cornea are very rare. The most frequent are dermoids, and they usually arise at the junction of the cornea and conjunctiva, especially on the temporal side. They are generally more or less hemispherical in shape and whitish in color, looking a good deal like normal skin. Hairs may grow from the surface. Fibroma, myxoma, papilloma, and sarcoma have also been reported. Cysts of the cornea usually arise from the implantation of epithelium after penetrating wounds. Either a cavity lined with epithelium is formed in the first place, or a mass of epithelial cells degenerates in its center. Cysts may also form under pterygia. The treatment of tumors and cysts of the cornea does not differ from that of similar growths elsewhere, due regard of course being had to the preservation of vision. William H Crisp.

**Cornification.**—The process of cornification is a physiological change by which the superficial cells of the epidermis acquire a horn-like character. It is also found normally in the corpuscles of the thymus. The albumin of the squamous cells of the deeper layers of the epidermis gradually becomes changed, as the cells approach the surface, into a resistant modified albuminoid body which possesses a hyaline homogeneous composition resembling that of bone. To this horny substance the name of keratin has been given. Under normal conditions the horny change first appears in the stratum granulosum, involving first the periphery of the cells and the prickle processes. As the change advances the cell protoplasm and the nuclei shrink until the cell bodies become thin and flattened horny scales. The nuclei at the same time gradually lose their staining power, and the entire process assumes the character of a mummifica-

tion necrosis, the water of the cells being almost entirely lost. Chemically, keratin is classed with the *albuminoids* or *scleroproteins*, simple proteins that are insoluble in all neutral solvents. Keratin resists digestion by both stomach and pancreatic juices.

In association with the formation of keratin small bodies of a hyaline nature appear in the prickle cells. These granules stain deeply with nuclear stains. In all portions of the epidermis where the stratum corneum is well developed the cells containing these granules form a definite layer known as the stratum granulosum. The substance of the granules has received the name of *keratohyalin*, and is believed to be derived from the nucleus. As the nucleus disappears with the formation of the granules, the latter may be supposed to be degeneration products of the nuclear chromatin. In the stratum lucidum the granules become translucent and evenly diffused through the cells (*eleidin*). In the stratum corneum the granules at first become more evident (keratin-granules), staining blue with Gram's stain, and as the cells approach the surface they become gradually changed into flattened, horny scales of compact keratin, staining yellow with Van Gieson's. The chemical nature of cornification and of the two substances, keratin and keratohyalin, is not yet clearly understood. By some the change is believed to be of the nature of a reduction, and not an oxidation process; but all theories and explanations are as yet unsatisfactory.

Cornification occurs pathologically in a great variety of conditions and under many forms. A hyperplasia of the horny layer of the entire body or of smaller areas frequently takes place (hyperkeratosis). This may be the result of external influences, as mechanical injury, infection, inflammations, etc. (corns, ichthyotic warts, callosities, etc.), or the change may be of intrinsic origin due to some congenital predisposition (ichthyosis). Disturbances of the normal processes of cornification may also take place (parakeratosis), such as scaly or plate-like desquamation which may occur in connection with infections or inflammations of the skin, or rarely without any apparent cause (*psoriasis*). In such cases the formation of keratin and keratohyalin appears to be unchanged. Pathological cornification also occurs in parts of the body where under normal conditions the horny change takes place only to a very slight extent or not at all. The epithelium of the skin glands may be involved in the hyperkeratosis of ichthyosis. Also in the mucous membranes of the mouth (*leucoplakia*), tongue (*hairy tongue*), esophagus, larynx, trachea, bronchi, middle ear, mastoid cells, pelvis of kidney, ureters, bladder, urethra, vagina (*pachydermia*), and cervix uteri a pathological cornification may occasionally take place. The epithelium of the vaginal portion of the cervix may acquire a very thick horny layer in prolapse of the uterus, when the cervix protrudes beyond the external genitals. Wherever squamous epithelium may replace columnar or transitional, a pathological keratinization may take place, and neoplasms developing from such metaplastic epithelium may also show keratinization (horny cancer of gall-bladder, pelvis of kidney, etc.)

In cholesteatomata, teratomata, and dermoid cysts pathological cornification may take place on a very large scale. The so-called "pearly bodies" are for the greater part made up of keratin. Horny change also occurs extensively in epitheliomata of the skin ("epithelial pearls"), forming large laminated masses in which calcification not infrequently takes place. Similar bodies are found in cholesteatomata of the brain and meninges (epidermal inclusions), and horny change has been reported to occur very rarely in carcinomata of the internal organs.

ALDRED SCOTT WARTHIN.

**Cornil, André Victor.**—Born at Cusset, France, June 17, 1837. He received the degree of Doctor of Medicine from the Paris Faculty in 1865; in 1870 he was made a Physician of the Lourcine Hospital; in 1882 he was chosen Professor of Histology, and in 1884 was elected a member of the Académie de Médecine. He was also prominent in politics being for many years a member of the French Senate. He died April 14, 1908.

Cornil was widely and favorably known as the author (in association with Ranvier) of the "Manuel d'histologie pathologique," 3d edition, Paris, 1902. Of his other published writings the following deserve special notice: "Les bactéries et leur rôle dans l'anatomie et l'histologie pathologique des maladies infectieuses" (in association with Babes); "Leçons sur les cirrhoses;" "Des différentes espèces de néphrites"; "Leçons sur l'anatomie pathologique des métrites," 1889; "Mélanges," 5 volumes.

A. H. B.

**Corns.**—See *Clavus*.

**Corn-silk.**—See *Zea*.

**Corn-smut.**—See *Ustilago*.

**Cornu Cutaneum.**—This subject receives a very brief consideration in systematic works on dermatology, because of its infrequency and relative unimportance. Nevertheless as a sort of freak or lusus naturæ it has always attracted a good deal of attention; and a large number of cases have been described at length and illustrated. Several compendious monographs have been published on the subject from time to time, and we learn that at the beginning of

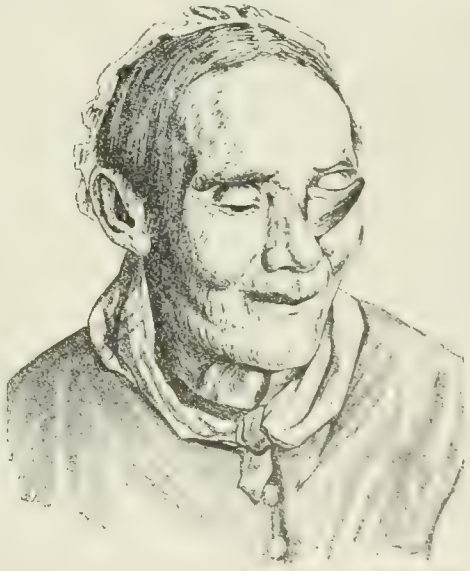


FIG. 1565.—Cornu Cutaneum of the Face. (After Mracek.)

the present century at least 200 cases had been reported, the earliest at the hands of Lanfrancus, the medieval surgeon.

Max Marcuse, a pupil of Prof. Jadassohn of Bern, devoted his Berlin graduation thesis to this subject (1901), and as a result of analysis of the available material states that the affection is somewhat more common in females, and that its maximum period of incidence is between fifty and seventy years. In about fifty per cent. of all cases the seat of predilection was the head and face. Here it may occur in the most unexpected sites—as the tongue and cornea. In fact in both man and animals there is a certain tendency to attack the eye and its appendages, as shown by the more recent literature. Another area

of predilection is the male genitals. Horns are usually single and in not over ten per cent. of cases are they multiple. The number in such cases, while as a rule not exceeding six or eight, has been known to amount to considerably over 100. Horns frequently reappear in localities from which they have been removed, whether by accident or design.

The *length* varies greatly. To deserve the title horn it should amount to two inches—according to some writers; but others give the term horn to formations not longer than a quarter inch. It is very evident that such short formations should not be incorporated into statistics, save with the understanding that they are bound to increase in size with time. The extreme length recorded is about one-third of a meter (13 inches.)

In regard to the *shape*, this is in a minority of cases straight—either cylindrical or conical, and projecting vertically above the skin. As a rule the horn has a spiral turn about its long axis, while its insertion into the skin is oblique. It may be curved upon the flat, like a talon. Paradoxical shapes are not uncommon. It often roots deeply into the skin—"like a candle in its socket." There is a tendency for the outlying skin to form a wall about the base of the horn.

The *color* varies anywhere from bright yellow to dark brown. Often the tip is of lighter hue than the base. The growth rate is extremely slow—years may be required for an increase in length of a few centimeters. In rare instances an extremely rapid growth is seen. A lateral increase in size almost never is observed.

In *consistency* the horn is usually all that its name implies, the hardness diminishing somewhat from base to tip. Horns are sometimes a nuisance mechanically—as when their occurrence on the penis prevents coitus; while in other cases their presence on the soles interferes with walking. Spontaneous recovery has been known to occur; in other words a permanent shedding takes place.

The relations of horns to other lesions are manifold. They not infrequently originate on some cutaneous lesion—wens, psoriasis, syphilis, etc.—and also appear to contribute to cancerous degeneration (in perhaps ten per cent. of all cases). This is not to be wondered at if we bear in mind that the lesion known as "keratoma senile" is believed to precede the the formation both of horns and of cutaneous cancer itself.

From the clinical viewpoint what we know of cutaneous horns may be told in a straightforward manner. Conditions, however, become confused as soon as we attempt to elucidate the intimate nature of these formations.

Marcuse attempts an etiological classification, as follows: (1) Cornua cutanea which are essentially neoplastic or stand in close relationship to new growths. Here belong horns developing in a basis of keratoma senile, those which appear in connection with carcinoma and xeroderma pigmentosum, and probably those which develop from wens. (2) Horns which develop in connection with multiple juvenile nevi—these are essentially congenital. (3) Horns which develop in connection with the evolution of specific infections, local diseases—notably syphilis, and gonorrhea. Concerning the claim that horns may develop on a basis of infectious juvenile warts, Marcuse has never yet seen them appear upon this foundation. (4) Horns which develop purely as a result of mechanical and chemical irritation. Here belong such as appear on a basis of scar-tissue, calluses, corns, and cauterized areas. Do all these various etiological types show special histological peculiarities? This question must be answered in the negative. Certain possibilities only may be isolated. Thus purely mechanical factors like irritations or pressure, such as cause ordinary corns and calluses, may also produce cutaneous horns in certain localities. Again the factors which produce ordinary hard warts or papillomata may also cause horns. Here we must assume that certain bacteria produce an acanthosis with more or less hyperkeratosis. Finally cutaneous horns may develop upon a congenital basis, as a result of deficiency of certain tissue elements. These are usually multiple and come under the head of congenital nevi.

From all that has been said it will appear that horns so called represent not an autonomous lesion but an accident in the course of development of a variety of conditions.

The *treatment* may be summed up briefly; in theory any keratolytic substance, and notably caustic potash solution, will dissolve the horn. But to be on the safe side the base of the latter should be excised along with the horn, and suture of the wound thus made should make the intervention final.

EDWARD PREBLE.

**Cornus.**—*Dogwood Bark; Flowering Dogwood.* The inner bark, preferably of the root, of *Cornus florida* L. (fam. *Cornaceæ*). The genus contains some thirty species distributed through the north temperate zone, a few getting into the tropics, in the mountains. They abound in bitter substances and tannin and act generally like the one here discussed. Several have been official, this being the last discarded. *C. florida* is a small tree, from twelve to thirty feet high, with slender, spreading branches, hard wood, ovate, pointed leaves, and very showy flower clusters. These are each supported by four large, broadly obovate and notched, white or purplish, petaloid bracts, which make the whole look like a large whitish flower; the real flowers, however, are minute, greenish-yellow, and closely aggregated in the midst of these bracts. Fruit clustered, small, scarlet, two-seeded drupes. It is common in the middle and southern portion of the United States, rarer and smaller in northern New England. When thrifty, it is very showy in blossom, and pretty also when the fruit is ripe.

Dogwood bark is in irregular flattish pieces, or in quills from two to four millimeters thick (⅛ in.), and of varying length. Both surfaces and the texture are reddish, in the stem bark rather dull, in the root bark a deep crimson purple. The outer surface is smoothish; the inner finely but prominently reticulate striate, and harsh to the touch, almost like fine sand paper; the fracture is short and brittle; the texture hard. Taste, bitter and astringent; odor, none. Dogwood is exclusively an American remedy.

It contains the amaroid *cornin*, in white, silky, very bitter crystals, soluble in alcohol and water. *Tannic acid, sugar, fatty oil,* and *resin* are among the other constituents. The cornin and the tannin are its active principles. Cornin has been used as a substitute for and an adulterant of quinine.

ACTION AND USE.—There is no reason to suppose that this medicine is anything more than a slightly astringent, bitter tonic; as such, however, it is good and useful. It was one of the drugs proposed as a substitute for cinchona in the treatment of intermittents, and, like them all, has been completely set aside by the general use of quinine. The fluid extract is given in doses of ♏ xv.–lx. (1.0–4.0), but the use of the tincture is preferable. HENRY H. RUSBY.

**Coronado Beach.**—See *California, Southern.*

**Coroner.**—The office of coroner (formerly crowner from M. L. *Coronarius*, in England a crown officer) is of very early origin, having been established in the reign of King Alfred (871–900) it is believed. The coroner was a municipal or county officer formerly charged with caring for the private property of the Crown; but in modern times he is an officer whose

function is to hold inquests on bodies of those supposed to have died violent deaths, or under suspicious circumstances, or those dying without medical attendance. Even when a physician is in attendance on a patient and the diagnosis is obscure, it can be made a "coroner's case" in order that an autopsy may reveal the cause of death, and a proper death certificate be given.

In England the coroner is elected and usually holds office for life, but may be removed by the Lord Chancellor for misconduct or incompetence; he is a salaried officer, and may appoint a deputy to act during his absence or illness, he must be either a barrister, a solicitor, or a physician.

*Functions of the Coroner.*—The powers of this magistrate were formerly much more comprehensive than at present. In addition to the duty of holding inquests upon the bodies of persons found dead from violent, sudden, suspicious, or unknown causes, he has also the duty of inquiring into the cause of incendiary fires, shipwrecks, etc.

An inquest must be held with, or in the presence of a jury consisting of twelve men, and must also be held *super visum corporis*, that is, the body must be seen both by the coroner and by the jury. The jury is sworn by the coroner, and charged to inquire how the deceased came by his death; witnesses are examined under oath, and the coroner has the power to order an autopsy and the attendance of medical witnesses. If the jury find that any one is guilty of murder or manslaughter, the coroner commits him to trial, and the accused may be indicted on the inquisition without presentation before the grand jury.

In Scotland there are no coroners, and the process employed is similar to that in France. The procurator fiscal, who has the investigation in charge, has a code of instructions drawn up by the lord advocate for his guidance, this code gives detailed directions to the medical men who have charge of the medical examinations, two physicians being employed. Their report is sent to the office of the crown agent at Edinburgh and by him to the advocate deputé; if he decides there is suspicion of crime, he reports back to the procurator fiscal for further facts; if in doubt he may bring the case before the crown officers, otherwise a criminal trial is much the same as in England.

In France two officers take the place of coroner, one a legal and the other a medical officer, the former, the *procureur de la république*, similar to our district attorney; the other officer, the medical, chosen for his superior training, who has charge of the medical examination of the body; sometimes two medical officers are employed. If their report warrants, evidence is presented to the magistrate, and if he deems it sufficient, an indictment is prepared for the *cour d'appel*, and a trial then takes place before a jury. In Germany a judicial officer (Staatsanwalt) has charge of such proceedings, his powers being similar to those of a district attorney; the police are under his control. The German code of regulations as to procedure in examinations of bodies, both judicial and medical, is very explicit.

In Russia the law is the same as, or similar in its provisions to that of France.

The system in Denmark is efficient, a judicial officer being appointed who has charge of all cases which he decides, without a jury; all medical questions are referred to a medical officer appointed for the purpose who reports to the judge the result of his examination, and also to the Royal Bureau of Health. The trial in case of indictment is before the county judge.

In the United States, with few exceptions the English law has been followed. The coroner, the coroner's jury, and the inquest are practically in the English form. The Coroners Court is a tribunal of record where the coroner holds his inquiries; coroner's inquest or investigation is held by the coroner with the aid of a jury, called and presided over by him; the verdict of the jury as to the cause of death is not conclusive, but may be the foundation of a criminal prosecution against the person charged. His functions are regulated by statute; in most of the States the coroner is elected by the electors of the county, and in a great many instances he is a physician; if not, in large towns and cities, he appoints a medical man as his deputy; in small towns the coroner employs physicians for each case.

The requisite number of jurors is either six or twelve; in New Hampshire it is limited to three, in Louisiana five, and seven in Tennessee. The jury is usually chosen from the residents of the neighborhood in which the death occurred. In Iowa, North and South Dakota from the electors; in Kentucky they must be "housekeepers;" in Utah "qualified residents;" in Washington, D. C., a "male inhabitant;" in West Virginia, a "suitable resident."

In large cities, New York, Philadelphia, etc., the coroner receives a salary, but in the smaller cities and towns he is paid from fees and mileage, which are provided by statute.

In Tennessee and Virginia he is appointed by the county court; in Illinois, Indiana, Maine, and New Hampshire, the Governor appoints him.

In Massachusetts, Connecticut, Rhode Island, Vermont, Utah, and Texas the office of coroner does not exist. In Massachusetts, a medical examiner acts instead, and in the other States mentioned a justice of the peace.

*The Medical Examiner.*—Taking the County of Suffolk, Mass., as an example, we find that the medical examiner for Suffolk County and the Associate medical examiner for said county shall be provided with rooms suitably furnished for the performance of their duties, the rent, furnishing, and office equipment of which shall be paid for by said county upon the approval of the Mayor of the city of Boston. He, the medical examiner, may in the name of the county contract such bills for clerical services, postage, stationery, printing, telephones, travelling, cost of removal of bodies to appropriate depositories and the care of the same, and for such other incidental expenses as may in the opinion of the examiner be necessary for the proper performance of his duty, to an amount not exceeding $833 in any one year, such bills to be paid by the county, after approval of the Auditor of Boston.

Medical examiners and associate medical examiners in other counties, shall receive fees as follows: for a view without autopsy, five dollars; for a view and autopsy, thirty dollars; and for travel ten cents a mile to and from the place of view.

The medical examiner shall receive an annual salary of four thousand ($4,000); the associate medical examiner six hundred and sixty-six dollars per year; should the associate serve in any year more than ten months he shall receive for such additional service, and be paid at the same rate to be deducted from the salary of the medical examiner at whose requests he serves.

A certificate from a medical examiner that he has viewed the body and made a personal inquiry into the cause of death, and is of the opinion that no further examination or judicial inquiry concerning the same is necessary, may be given to any corporation authorized to cremate bodies, after forty-eight hours have elapsed, unless caused by contagious disease.

Every railroad and street railway corporation shall give immediate notice of an accident on its road which results in a loss of life, to the medical examiner of the county who resides nearest to the place of accident, failure so to notify to pay a forfeit of not more than one hundred dollars ($100).

In some States the coroner has peculiar functions

added to the usual duties. In Kentucky an inquest may be held in cases of house breaking, in Mississippi the coroner is the county ranger, taking charge of stray horses, mules, etc.

In Wisconsin the coroner is ex-officio a deputy fish and game warden and upon notice must assist the state warden. In Colorado, he must look into mining accidents, seize gambling implements, traps, nets, and snares. In Alabama it is required that the coroner shall be keeper of the jail when the sheriff is imprisoned, and when the coroner is imprisoned a special coroner may be appointed.

WILLIAM OLIVER MOORE.

**Coronilla.**—A genus (fam. *Leguminosæ*) of some twenty species, of Europe, Northern Africa, and Western Asia, some cultivated for ornament. Several of these, notably *C. scorpioides* (Medic) Koch, act powerfully upon the heart, stimulating it and, apparently through increased blood pressure, producing marked diuresis. These properties reside in the glucoside *Coronillin* ($C_7H_{12}O_5$), a yellowish powder, soluble in both water and alcohol. It possesses the same properties as the drug, which are almost identical with those of digitalis, and it is indicated and contraindicated like that drug. Coronillin has been given in doses of gr. iss. to iij. (0.09–0.18) five or six times in the twenty-four hours. HENRY H. RUSBY.

**Corpora Amylacea.**—These bodies are small, round, homogeneous, or concentrically stratified concretions occurring most frequently in the prostate, nervous system, and lung. Their concentric stratification resembles very much that of starch grains, and this with the fact that with iodine, or with iodine and sulphuric acid, they frequently take on the characteristic blue color has led to their name and to their being classed with amyloid. It is, however, evident that they have an entirely different significance from that of the progressive amyloid change beginning in the walls of blood-vessels, and they should be regarded as being of different pathological origin and nature.

While these bodies frequently assume with iodine and sulphuric acid colors varying from blue, brownish red, and green to yellow, it is stated that they but rarely give the amyloid reactions with the aniline dyes, and then only to a slight degree, usually in the central portion of the concretion. The writer has been unable to obtain any reaction from these bodies with the aniline dyes which he regarded as characteristic of amyloid, and it is his opinion that they should be classed with the colloid or colloid-like bodies rather than with amyloid. In the majority of cases these concretions react to stains in a manner similar to that of colloid. With Weigert's fibrin stain they take a deep violet color. Many corpora amylacea stain red with the Best glycogen stain, although glycogen may not form any part of their composition. They are essentially a local product dependent upon local conditions, and are for the greater part derived from epithelial cells and represent a transformed gland secretion. In this respect their origin is the same as that of epithelial hyalin. In the nervous system they arise from degeneration of either the neuroglia cells or the axis-cylinders, and the chemical nature of the concretions found in the brain and spinal cord must be different from that of those formed in the prostate and lungs. This is further shown by difference in appearances, staining reaction, etc., exhibited by the concretions found in these different regions. According to Ophüls some of the corpora amylacea are formed by the successive deposit of obscurely crystalline needles of protein material.

In the prostate the bodies lie in the lumina of the gland spaces. They vary in size from a leucocyte to large concretions visible to the naked eye. They may be so numerous as to give the cut surface of the organ a brown, granular appearance. The free concretions may be obtained for examination by scrapings taken from the cut surface of the organ and examined upon the slide. Pressure upon the cover glass produces numerous radiating fissures in the firm bodies. In unstained sections these concretions may appear colorless, brown, dark brown, or yellow, and the striations may show more or less distinctly. In sections from hardened material the majority of the bodies are torn out by the microtome knife, or drop out in the handling of the section. Their consistence becomes very firm, especially in material embedded in paraffin, so that they not infrequently turn the edges of the knife. In this respect they resemble the colloid of the thyroid. In stained preparations the concretions may show a great variety of forms and colors. The gland spaces may be filled with large and small bodies; or concretions of different size, shape, and color may be conglomerated together by a lighter hyaline substance. The darker prostatic concretions show most frequently a concentric or radiating striation. The central portion of the body may consist of a hyaline nucleus, or the periphery may be light-colored and hyaline. Frequently the peripheral zone of the concretion is darker and firmer in consistence than the central portion. The larger concretions may show alternating zones of light and dark colors, or may be made up of conglomerated granules of different shades of color. Deposits of lime salts and blood pigment are not infrequently found in the older brown bodies. As a rule, the number of the prostatic concretions is greatest in old age, but they also occur in the prostates of newly born infants. Moreover, they are not a constant accompaniment of senility, and their exact physiological or pathological significance is as yet unknown. They must be regarded as the product of degenerated epithelium or transformed prostatic secretion.

The corpora amylacea of the nervous system are found most abundantly in the ependyma of the ventricles, meninges, the sclerotic areas of the brain and cord, and in atrophic nerves. They are especially common in the areas of degeneration in tabes dorsalis, and are also of frequent occurrence in senile atrophy of nervous structures. They differ in many respects from the concretions of the prostate and lung, being, as a rule, much smaller than the latter, though many times larger than the nuclei of the neuroglia cells. They are usually homogeneous, and only rarely show faint striations. They are round or oval in form, possess no definite nucleus, and are sharply outlined peripherally. They stain very deeply with hematoxylin, and for this reason have been thought to be formed from degeneration products of the nuclei of the glia cells. By some writers they are regarded as myelin products arising from the degeneration of nerve fibers. Others consider them to be derived from changed albuminoid constituents arising from the cells.

Corpora amylacea are found in the lungs under many varying conditions: in acute and chronic pneumonias, in emphysema, in hemorrhagic infarction, in the neighborhood of tumor nodules, in tuberculous areas, and in the alveoli near the inflamed pleura. The writer has also observed them in lungs showing no pathological changes. In pneumonia they are frequently found imbedded in masses of cellular and fibrinous exudate. They appear as round or oval homogeneous bodies, the larger ones frequently showing striation. In the central portion of the body degenerated cells, particles of carbon, blood pigment, etc., are often found, forming a nucleus around which the deposit of the concretion has taken place, through either the precipitation of albuminous exudate or the accumulation of the products of degeneration of

epithelial cells. In so far as the writer's experience goes, the corpora amylacea of the lung never give an amyloid reaction with the aniline dyes. With other stains they react similarly to the concretions of the prostate.

Corpora amylacea have also been observed in carcinomata, in inflammatory areas, in old extravasations, and in the glands about the mouth of the urethra in the female. The writer has also seen them in tumors of the parotid and mammary glands, in cysts of the ovary and kidneys, in the seminal vesicles, vas deferens, and epididymis, and in the small closed gland spaces near the prostate which are probably vestiges of the ducts of Müller. In all of these cases the origin of the concretions is apparently the same; the bodies represent transformed albuminoid constituents of epithelial secretions and have no chemical relationship to amyloid.

ALDRED SCOTT WARTHIN.

**Corpora Quadrigemina.**—This is the older anatomical name of two rounded structures forming the roof of the midbrain. From the topographical standpoint they are structures which flux one into the other. Anatomically they are very distinct. The anterior quadrigeminal body is mostly composed of optic pathways and is a part of the ophthalmencephalon, the anatomy of which is described in the article on *Brain, Anatomy of*, vol. ii., p. 318. The posterior quadrigeminal bodies are parts of the auditory pathway, and thus belong in part to the audito-encephalon. For anatomy see vol. ii., p. 308. The anterior corpus is also termed the colliculus superior; the posterior is named the colliculus inferior, under which separate names they are treated of in this volume. Also see for lesions of the midbrain; *Brain, Midbrain Diseases*, vol. ii., pp. 395 and 397 (Corpora Quadrigemina Syndromes).

SMITH ELY JELLIFFE.

**Corpora Striata.**—Under this term in descriptive anatomy two fairly distinct structures are to be distinguished, the caudate and the lenticular nuclei. Both are included under the broad term basal ganglia. They are not anatomical nor physiological units, hence they have no functions in the strict sense of the word. They both contain ganglion cells and tract pathways, *i.e.* synaptic junctions of certain pathways, mostly motor, and direct transmission fibers of other motor and possibly sensory pathways. It is illogical, in a sense, to deal with them as definite structures having definite functions. They will be found in this work under the titles, *Nucleus Caudatus*, and *Nucleus Lenticularis*. The general anatomy of these regions has already been described in the article on *Brain, Anatomy of*, vol. ii., p. 331 *et seq.*

SMITH ELY JELLIFFE.

**Corradi, Alfonso.**—Born in the Province of Emilia, Italy, on March 6, 1833. He received the degree of Doctor of Medicine from the University of Bologna in 1855. In 1859, after a competitive examination, he was made Professor of General Pathology in the University of Modena, and four years later (1863) he was invited to fill the corresponding Chair in the University of Palermo. From 1867 to the time of his death, which occurred on November 28, 1892, he was Professor of General Therapeutics, Experimental Pharmacology, and Pharmacognosis in the University of Pavia.

Corradi was one of the most distinguished modern writers on epidemiological matters and also at the same time an original investigator in the same field. Of his numerous contributions to this branch of medical literature only the following may here be cited: "Annali delle epidemie in Italia dalle prime memorie sino al 1850," seven volumes, Bologna, 1865–1886; "Dell' odierna diminuzione della podagra," Bologna, 1860; "Della infermità di Torquato Tasso, prima parte," Bologna, 1881; and "Del veleno dei funghi," Annal. univ. di medicina, vol. ccxliii., 1878. A. H. B.

**Corrigan, Sir Dominic John.**—Born in Dublin, Ireland, on December 1, 1802. He studied medicine partly in his native city, under the guidance of O'Kelly, and partly at the University of Edinburgh, from which institution both he and William Stokes, of Dublin, received their medical degrees at the same time (in 1825). Upon his return home he held the position of Instructor of Medicine in three different schools in succession—first in that of Digges Street, then in that of Peter Street, and finally in the Richmond Hospital. In 1830 he was appointed Physician to the Jervis Street Hospital. Here, notwithstanding the fact that he had only six beds under his control, he was able to make that series of investigations into the symptomatology of heart diseases which in time became celebrated. The reports of these observations are to be found in the *Lancet* for the year 1829, in Johnson's Medico-Chirurgical Review for 1830, in the *Dublin Journal of Medical Sciences* for 1832, 1836, and 1838, and in the *Edinburgh Medical and Surgical Journal* for 1832; and in these reports is described the condition to which Trousseau gave the name of "Corrigan's disease" (aortic insufficiency). The expression "Corrigan's pulse" also dates back to this period. In 1840 he was made Physician to the Whitworth and the Hardwicke Hospitals. In 1853 he published his celebrated "Lectures on the Nature and Treatment of Fever." In 1866 he was made a baronet. His death occurred on February 1, 1880.

In addition to the writings mentioned above, Corrigan published, in 1842, "Observations on a Draft Bill for the Regulation and Support of Medical Charities in Ireland"; and, in 1846, "On Famine and Fever a Cause and Effect in Ireland, etc." A. H. B.

**Corti, Alfonso.**—Born in Italy. Studied medicine in Vienna in the early forties of the nineteenth century. He was the first to give a full and minute description of the remarkable structures which, in vertical cross-sections of the cochlea, are placed like an arch above that spiral, diaphragm-like membrane which bears the name of *lamina spiralis*. The whole complicated mechanism has, since his description of its individual parts and of the manner in which they are disposed, been given the name of "Corti's organ." Some of the older anatomists had already, many years before, furnished imperfect descriptions of the component parts of the mechanism, but it was reserved for Corti to give to the world such a faithful picture of these parts that nobody, since his time, has been able materially to add to its completeness. Corti was also able, by reason of his extraordinary technical skill in histological work, to prepare remarkably beautiful specimens of the nerve fibers and spherical ganglionic bodies of the retina, and to demonstrate the connection between the nerve fibers of the retina and the multipolar ganglion cells. The exact date of death of the Marquis of Corti—for this is the title which rightly belonged to him—is not known.

Corti's first published writing bore the title: "De systemate vasorum psammosauri grisei," Vienna, 1847. The following are the titles of his later publications: "Beitrag zur Anatomie der Retina," in Mueller's Archiv, 1850; "Recherches sur l'organe de l'ouie des mammifères," in the Zeitschrift für wissenschaftliche Zoologie, Jahrgang,

1851; and "Histologische Untersuchungen, angestellt an einem Elephanten," ibidem, Jahrgang, 1854.
A. H. B.

**Corvisart, Jean Nicolas.**—Born February 15, 1755, in Drécourt, France. His father destined him for the Bar, but young Corvisart took no interest in the studies which he was obliged to pursue with this career in view. Accidental circumstances put him in the way of listening to the instruction given by the celebrated physician, Antoine Petit, and he speedily became convinced that medicine was his true vocation. The poverty of the family and their strong opposition to his adoption of a medical career made it very difficult for Corvisart to carry out his plan, but he persevered and finally succeeded in overcoming all the obstacles that stood in his way. His favorite instructors were Desault and Desbois de Rochefort, both of whom owed much of their celebrity to the fact that they were the first in France to give clinical instruction in a regular manner. For some frivolous reason he was unwilling to wear a wig, as was the fashion at that time, and it was to this circumstance that he owed his failure to receive the appointment of attending physician on the staff of the hospital which had just been founded in Paris by Monsieur Necker. At a later date, however, he had reason to be thankful that he did not succeed in securing this coveted honor, for his non-success in this affair left him free to accept the more advantageous position of attending physician to l'Hôpital de la Charité. Corvisart, following the practice of his predecessor, was most faithful in giving clinical instruction, and thus he gradually acquired for himself the reputation of being the leading medical practitioner of his day, and for France the glory of being the center of medical knowledge. Immediately upon the establishment of the Consulate, he was made Government Physician, in association with Barthez; and shortly afterward Napoleon, who had become Emperor, appointed him his First Physician. This elevation to such a high position afforded Corvisart the opportunity of displaying before his countrymen the true nobility of his character. In the large number of positions which he was called upon to fill he utilized the power which had thus been conferred upon him, in appointing men of scientific merit and recognized excellence of character. In several instances he selected for positions of great responsibility men who had spoken or written against him. His public duties soon occupied so large a portion of his time that he felt obliged, in 1807, to resign the different chairs (clinical medicine and practice of medicine) which he had held up to that time. In 1814, after the fall of the Imperial Government, Corvisart, whose health had begun to give way, retired to the country for the remainder of his days. His death occurred on September 18, 1821.

The following are the titles of the only two published works of Corvisart that call for special mention: "Essai sur les maladies et les lésions organiques du coeur et des gros vaisseaux," Paris, 1806; and "Nouvelle methode pour reconnaître les maladies internes de la poitrine, par la percussion de cette cavité," Paris, 1808. The latter book, although purporting to be simply a translation of Auenbrugger's work, is almost an original treatise on the subject, by reason of the extensive and important comments which Corvisart added. (Dict. Hist. de la Médecine.) A. H. B.

**Coryza.**—See *Rhinitis, Acute.*

**Cosmetics.**—The subject of cosmetics in general covers a field so wide that it will be possible in this connection to include only a bird's-eye survey of those preparations relating chiefly to the beautification, preservation, and rejuvenation of the skin and hair.

Cosmetics for the Skin.—*Cold cream* is one of the most frequently employed cosmetics, and with reason. Fats soften, clarify, and impart gloss to the superficial layer of the epidermis. It is on account of these beautifying effects that cold cream containing fat derives its common appellations "skin food" and "skin nourisher."

A certain amount of fat is essential to the beauty and good condition of the skin. Greasy skins, however, are not only not benefited by the application of cold cream, but they may even be injured. Dry skins, on the contrary, are greatly improved by such inunctions. Besides imparting fullness and softness to the skin, thus making it pliant, cold cream (fat) furnishes for the skin a waterproof, protective coating. Cold cream is also very useful as a cleansing agent, since oil or fat has a saponifying action on the cutaneous excretions and is on this account a good vehicle for removing dirt. The ancient Romans and Greeks were well acquainted with this fact and commonly employed oil inunctions for cleansing the skin. A wide variety of fats is open to the choice of the cosmetic manufacturer—animal, vegetable, and mineral kingdoms contributing. Lanolin, lard, and marrow fat; olive, almond, sesame, and palm oil, and cocoa butter; and finally vaseline and paraffin, are all employed.

Cold cream made according to the official formula is a standard preparation and many are the variations played on this formula to please the whims of the beauty-seeker.

A well-made cold cream is neither waxy nor translucent, but more like butter in consistence, and snowy white, with a faint rose perfume. It should be absolutely guiltless of rancidity. Cold cream lasts much longer with the addition of five per cent. boric acid in impalpable powder.

Official cold cream, Unguentum Aquæ Rosæ, is made according to the following formula:

| | |
|---|---|
| Spermaceti | ℥i av. gr. 400. |
| White wax | ℥i av. gr. 370. |
| Expressed oil of almond | fl ℥ ix. |
| Stronger rose water | fl ℥ iii. |
| Sodium borate in fine powder | gr. xxxiii. |

A cream much in vogue among Parisians consists of:

| | |
|---|---|
| Oil of sweet almonds | 2 ounces (scant measure). |
| Spermaceti | ½ ounce (scant measure). |
| White wax | ½ ounce. |
| Rose water | 1 fluidounce. |

A cream of very simple composition is:

| | |
|---|---|
| Lanolin | ℥iiss. |
| Ol. cacao | ℥vii. |
| Vanillin | gtt. viii. |

Hydrogen peroxide is sometimes incorporated in cream for bleaching purposes as in:

| | |
|---|---|
| Zinc oxide | 5 parts. |
| Lanolin (anhydrated) | 5 parts. |
| Cold cream | 5 parts. |
| White vaselin | 5 parts. |
| Hydrogen peroxide | 30 parts. |
| Scent as desired. | |

Cucumbers are also extolled for their bleaching action and are accordingly sometimes used as an ingredient of cold cream:

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|---|---|
| Cucumber juice | 2 ounces. |
| White wax | 1 ounce. |
| Spermaceti | 1 ounce. |
| Almond oil | 4 ounces. |
| Orange-flower water | 1 ounce. |

A witch hazel cold cream is made of:

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|---|---|
| White petrolatum | 9 ounces. |
| White wax | 1½ ounces. |
| Spermaceti | 1½ ounces. |
| Distilled extract of witch hazel | 3 fluid ounces. |
| Perfume as desired. | |

A good camphor ice contains the following ingredients:

| | |
|---|---|
| Oil of sweet almonds | 2 ounces. |
| Spermaceti | 4 ounces. |
| White wax | 2 ounces. |
| Camphor | ½ ounce. |

There is a certain demand, especially in winter, for lip salves for dry, chapped lips. The following formula is used for this purpose:

| | |
|---|---|
| ℞. Butyr. cacao | ʒi. |
| Ol. amygdal. dulc. | ʒii. |
| Liquef. et admisce sub agitando : | |
| Vitelli ovi | No. 1 |
| Ol. neroli | gtt. iii. |
| Carmini | gr. iss.–iii. |

A white lip salve may be obtained by the omission of the carmine.

The popular idea that the application of preparations containing oil or grease encourages the growth of superfluous hair has created a wide demand for greaseless or so-called vanishing creams.

The following recipe is often used for greaseless rose cream: Put thirty grains of white ribbon tragacanth into seven ounces of rose water, letting it soften for two days. Then squeeze the mass through a coarse jelly-bag and add one ounce each of glycerin and alcohol. A drop of attar of rose may be used to scent the cream. Immediately after bathing the skin apply the cream, rubbing it on gently until the skin is dry.

And a vanishing cream may be made of:

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|---|---|
| Starch | 5 parts. |
| Rose water | 5 parts. |
| Glycerin | 90 parts. |
| Oil of rose | 2 drops to 3 ounces of glycerin. |

An excellent type of the hand lotions used in hospitals, a fat-free lotion, is the following:

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|---|---|
| Tragacanth | 80 grains. |
| Glycerin | ½ ounce. |
| Boric acid | ½ ounce. |
| Oil of bergamot | 5 drops. |
| Oil of rose | 1 drop. |
| Oil of lavender | 2 drops. |
| Water to make | 1 pint. |

Dissolve thoroughly by gentle heat.

A very popular preparation is heliotrope glycerin lotion:

| | |
|---|---|
| Glycerin | 16 fluidounces. |
| Distilled water | 16 fluidounces. |
| Borax | 2 drachms. |
| Extract of white heliotrope | q.s. |

Gylcerin is used quite extensively in cosmetics. Paschkis recommends glycerin cold cream:

| | |
|---|---|
| ℞. Amyli | gr. lxxx. |
| Aq. rosæ | gtt. xc. |
| Glycerini | ʒ iii. |
| Ol. rosæ | gtt. ii. |

Junonia glycerin paste used as a substitute for soap in washing face and hands is made according to the following formula:

| | |
|---|---|
| ℞. Tragacanth. pulv | gr. cix. |
| Aq. rosæ | ʒ v. |
| Glycerini | ʒ iss. |
| Tr. benzoin | ʒ iii. |
| Aq. aurant. flor | gtt. v. |

Preparations of this nature are commonly known as cosmetic jellies.

*Emulsions* constitute another class of cosmetics. These preparations when mixed with water make a milky fluid. Vegetable milk in its different forms is merely an emulsion already containing enough water to give the characteristic milky appearance. It is well to remember that these preparations should be briskly shaken before being used since most of them contain balsams, oils, or resins that are insoluble in water. It is believed that the balsams and resins owing to their mechanical action tend to soften and smooth out wrinkles.

A variety of alluring names are applied to preparations of this nature. "Lait de Jeunesse" is a simple example:

| | |
|---|---|
| ℞. Tr. benzoini | ʒ iii |
| Aq. rosæ | ʒ iiss. |

A more elaborate formula is that of "Eau de Mille Fleurs":

| | |
|---|---|
| ℞. Balsam peruv | gtt. xl |
| Ol. bergam | gtt. lxviii. |
| Ol. caryophyll | gtt. xxx. |
| Ol. aurant. flor | gtt. viii. |
| Ess. moschi | gtt. viii. |
| Spt. vini | ʒ iv |
| Aq. aurant. flor | ʒ iss. |

Honey and almond cream is prepared from:

| | |
|---|---|
| Bitter almonds | 1 ounce. |
| Yolk of egg | 1 [illegible] |
| Honey | 1 ounce. |
| Oil of sweet almonds | 2 ounces. |
| Oil of bergamot | 15 minims. |
| Oil of lemon | 12 minims. |
| Oil of cloves | 12 minims. |

Paschkis recommends a paste for obliterating wrinkles:

| | |
|---|---|
| ℞. Amygdal. dulc | ʒ i |
| Amygdal. amar | gr. cl |
| Balsam. peruv. | |
| Mellis alb. | āā gtt. lxxxv. |

Borax, an excellent cosmetic, is an ingredient in Hufeland's Beauty-water:

| | |
|---|---|
| ℞. Boracis | gr. xxx. |
| Aq. rosæ | |
| Aq. flor. naphæ | āā ʒ iiiss. |

Another substance extensively employed in cosmetics is sulphur. Common forms are flowers of sulphur, and milk of sulphur which when fresh consists of a mixture of insoluble and colloid sulphur.

As an example of preparations containing sulphur a recipe for Kummerfeld's Water will serve:

| | |
|---|---|
| ℞. Sulph. præcip | gr. clxxx. |
| Camphor | gr. xv. |
| Mucil. gummi arab | gr. xc. |
| Mix and add: | |
| Aq. calcis | |
| Aq. rosæ | āā ʒ iiiss. |

The alkalies and acids also play a part in cosmetic preparations for the skin.

Hebra's freckle ointment is an example of the first class:

| | |
|---|---|
| ℞. Hydrarg. præc. alb. | |
| Bismuth subnit. | āā gr. lxxx. |
| Ung. glyceris | ʒ vi. |

Salicylic dusting-powder is a type of the latter:

| | |
|---|---|
| ℞. Acid. salicyl | gr. xlv. |
| Amyli tritici | gr. clx. |
| Talci | ʒ ii. |

A preparation recommended for removing freckles is called Eau de Hébé: Distilled vinegar, 660 grams; lemons chopped fine, 135 grams; 85 per cent. alcohol, 88 grams; lavender oil, 23 grams; water, 88 grams; cedar oil, 6 grams.

The subject of *soaps* which are used in the cosmetic art in many forms—soap powders, soap balls, soap emulsions—is too large to be included in the present article. Suffice it to say that the chief use of soap is the simple one of cleansing. The use of the widely advertised and much vaunted medicinal soaps is best left to the direction of the dermatologist. Meals and pastes commonly made from almonds are often used as substitutes for soap, especially in the case of delicate and irritable skins.

*Injurious Compounds.*—Of the many secret preparations for the skin, particularly that of the face, some of them with impossible claims, others injurious to the skin or dangerous to health, the following will serve as examples.

A certain freckle cream contains white precipitate, basic bismuth nitrate, lanolin, and ethereal oils. This cream not only falls far short of the claims made for it but it may prove dangerous. A face ointment is made up of a white precipitate ointment mixed with bismuth white, the whole perfumed with rose oil. A face wash has for its ingredients about 12–13

parts of commercial (plumbiferous) zinc oxide, 1½–2 parts of bismuth oxychloride, 86–87 parts of water, with the addition of a few drops of glycerin, rose water, and carbolic acid.

A Parisian wrinkle specific used also as a skin bleach is aromatic water containing mercuric chloride and lead chloride.

Another injurious face wash consists of scented water containing calomel, lead carbonate, and a little alcohol.

A complexion balsam is made up of equal parts of egg albumin and glycerin, scented. Glycerin alone would do the same work.

A harmless wrinkle lotion and beautifying wash of poetic name is a weak alcoholic extract of styrax, slightly alkaline.

*Powders* may be classified according to their source as vegetable and mineral. In the first group belong wheat starch, amylum tritici, a fine powder of bluish white tinge; rice powder, the popular poudre de riz, amylum oryzæ, dead white; potato starch, amylum solani, a powder of coarser grain, with a yellow cast. Powdered orris root, pulvis rhizomatis iridis florentinæ, is of service on account of its fragrance and is added to other powders for the purpose of scenting them. Vegetable powders are useful as absorbents. Starch possesses this quality, being distinctly hygroscopic. But starch is disadvantageous in that it becomes sticky by combining with the perspiration. Not infrequently does the damp powder roll into balls and become sour, especially in hot weather. It is then irritating to the skin. A great deal of the so-called rice powder is in reality potato starch thoroughly washed by levigation. In the case of wheat starch the cohesion between the separate granules is a disadvantage. Much ingenuity is expended upon a variety of names for practically the same article—starch—which is sometimes used plain. Oftener, however, it is perfumed and tinted to meet different tastes and complexions, for in these days account is taken of many factors, the color and texture of the skin, the season, and the light—sunlight or artificial light—in which the powder is to be used.

Among the most useful mineral powders are Venetian talc, magnesium carbonate which is very absorbent, zinc oxide, silicate of magnesium, French chalk, and soapstone powder, white and sparkling with a greasy feel. Lead and bismuth are infrequently used.

Talcum is very absorbent and never decomposes. It is deservedly the most popular of powders.

The chief use of powders is to beautify the skin. In addition to their esthetic use powders possess certain remedial properties. To a certain extent they afford protection to the skin; they are cooling, and as has been said they are absorbent. On account of these qualities the use of bland cosmetic powders is very agreeable. The substances commonly used as powders are innocuous, and so are the coloring matters employed for tinting them. But the lead and bismuth salts are dangerous, especially the former, and their use in powders should not be allowed. The common tradition that powders clog the skin cannot be accepted. If powder be combined with a greasy cold cream, and if the rules of cleanliness are not observed, it is quite possible that "blackheads" will eventually form. Otherwise the moderate use of bland cosmetic powders is not apt to be injurious to the skin. In the manufacture of powders, the greatest care should be taken to render them smooth and impalpable, else they will not be of fine grade.

The pigment used to give flesh tints to powders for blondes is plain carmine. Burnt umber or sienna, or sometimes fine yellow ochre, is used in the manufacture of powder for brunettes.

The scent varies with the color. White powder is perfumed with bergamot oil, 3; ylang-ylang oil, 2; neroli oil, 2; eau de cologne, 20 grams.

Red powder is scented with bergamot oil, 3; rose oil, 2; white rose extract, 2 grams; Ceylon cinnamon oil and musk tincture colored with carmine, 10 drops of each.

Yellow powder is colored with equal parts of light and dark cadmium yellow, and scented with bergamot oil, 3; clove oil, 1; cedarwood oil, 1; patchouli oil, 1; extract of new mown hay, 20 grams.

Black powder used for theatrical purposes is colored with moist prepared vine charcoal or ivory black. The perfume used for this powder is Portugal oil, 4; lavender oil, 1; petit grain oil, 1; ess. Boquet extract, 15 grams; musk tincture, 20 drops.

An excellent powder has the following formula: Zinc white, 200 grams; precipitated chalk, 3,000; steatite powder, 500; wheat starch, 1,000; essence of white rose, 30; jasmine extract, 30; orange-flower extract, 30; cassia extract, 30; musk tincture, 7½ grams.

Another white face powder is prepared from the following formula: Finest levigated zinc white, 50 grams; Venetian talc, 50 grams; magnesium carbonate, 50 grams; rose oil, 20 drops; orris oil, 30 drops. These ingredients are thoroughly blended.

A rose powder is made by combining 150 grams of the above with 0.5 grams of carmine.

Unna's pulvis cuticolor is a good flesh-tinted powder:

| | | |
|---|---|---|
| ℞. | Zinci oridi | ʒ ss. |
| | Magnes. carb. pond. | |
| | Kaolin | āā grs. xlvi. |
| | Bol. rubr | ʒ ss. |
| | Amyl. oryzæ | ʒ iiss. |

A liquid powder that is of use in protecting the face from the ravages of the sun's rays, and in slight irritations of the skin consists of:

| | |
|---|---|
| Powdered calamine | 1 dram. |
| Zinc oxide | 3 drams. |
| Glycerin | 1 dram. |
| Lime water | 1 ounce. |
| Rose water or plain water up to | 4 ounces. |

The lotion should be well shaken before being used. If a colorless preparation is desired the calamine may be omitted.

Certain much vaunted facial cosmetics (white) contain lead, others (red) cinnabar. Not only are such preparations poisonous, but a most unhappy state of affairs awaits the user of cosmetics containing lead who may afterwards expose the skin to the action of sulphur as in the case of sulphur baths. Such a victim becomes literally "black in the face." The combination of lead with sulphureted hydrogen forms sulphide of lead with disastrous effect upon beauty. Soap and water have no influence on discoloration of this kind which looks like indelible ink. The only way to get rid of the black plugs in the pores is to squeeze them out.

A powder of this kind is prepared according to the following formula: White lead, 14; talc, 7; magnesia, 1. This product is tinted with carmine and perfumed with volatile oils.

*Paints.*—In order to make grease powder, 3 to 5 per cent. of lanolinum anhydricum is added to the above powder. Spermaceti or, in cold weather, cacao butter may be used for this purpose.

The following is a good example of a formula for grease paint: One ounce and 5 drams of pulvis cosmeticus (simple white toilet powder) and from 23 to 38 grains of adeps lanæ are blended. Rose powder, Rachel's yellow powder, or light yellow powder may be substituted for the white at will.

Red grease paint is colored with carthamine, a pigment obtained from the flowers of the safflower, *Carthamus tinctorius*. A formula in use is the following:

| | | |
|---|---|---|
| ℞. | Carthamini | gr xv |
| | Talci veneti alcoholisati | ʒ ii gr xviii. |
| | Spermaceti | ʒ iiss |
| | Olei amygdalarum dulcium | ʒ v ♏ xxxviii. |

Grease paint is sometimes moulded in the form of sticks.

The number of oil paints on the market is legion. Paschkis gives this formula for white oil paint:

| | | |
|---|---|---|
| ℞. | Talci venet. alcohol. | ʒ iiss. |
| | Zinci oxid. subt. | gr. xv. |
| | Spermaceti | ʒ iii. |
| | Ol. amygdal. dulc. | ʒ vi. |

James gives a formula for red oil paint:

| | | |
|---|---|---|
| ℞. | Carthamini | gtt. xvii. |
| | Talci venet alcohol. | ʒ iiss. |
| | Spermaceti | ʒ iii. |
| | Ol. amygdal. dulc. | ʒ vi. |

Water paints are made by suspending white insoluble substances in perfumed water. The use of certain resinous solutions or of solutions of volatile oils assists suspension. The carmine is dissolved in ammonia and is commonly perfumed wit attar of roses. The following formulas for fluid paint, both white and red are given by a well-known authority.

Fluid white paint (Blanc de neige)

| | | |
|---|---|---|
| ℞. | Zinci oxid | ʒ iii. |
| | Talci venet | ʒ vi. |
| | Aq. colon. | |
| | Aq. rosæ | āā ʒ iv. |

Fluid red paint (Debay's rose liquide)

| | | |
|---|---|---|
| ℞. | Potass oxal. | gr. vii. |
| | Aq. dest. | ʒ viii. |
| | Alcohol | ʒ iv. |
| | Carmin. opt. | gr. vii. |
| | Aq. ammon. fort. | ♏ iiiss. |

Lamp-black, or bone-black is employed in the manufacture of black paint. Indian ink the use of which is a relic of Assyrian and Roman times is dissolved is rose water and applied to the part by means of a camel's hair brush.

An eyebrow pencil is made of one-half pound of suet; one-fourth pound of curd soap; and sufficient ivory black. The mixture may be rolled into spills, or is put into a metal case.

The theatrical liquid "blanc de perle" is made up of one pint of rose or orange-flower water and four ounces of oxide of bismuth. These ingredients are mixed by long trituration. Before using the preparation should be well shaken. After being left on the skin for some time the formation of black bismuth sulphide results and the cosmetic becomes yellow. Liquid vegetable rouge, used particularly for tinting the lips, is compounded of sixty grams of ammonia, thirty-five grams of carmine, seventy grams of esprit de roses (triple), and two liters of rose water.

Rouge en pâte is prepared by triturating finely powdered carmine, thirty grams; talc (steatite), six hundred grams; and gum arabic, fifty grams. Water is added to form a paste.

Rouge en feuilles or leaf rouge is made by covering small circular discs of very smooth paper with carmine. The latter is made to adhere to the paper by the use of gum arabic.

Long-continued use of carmine turns the skin dry and yellow. Vermilion is an active poison. Black preparations used on the skin for theatrical purposes are very apt to injure the skin.

It may be worth while to note a device used to give color to the cheeks without the use of pigment. Powdered siliceous sponge which is made up of innumerable siliceous needles is rubbed into the cheeks. The needles prick into the skin and irritate it sufficiently to make it red.

Liquid cosmetics commonly known as pearl white, liquid pearl, liquid face paint, and enamel are generally sold in white (opaque) bottles. When the face is "enameled" the facial muscles must be kept as motionless as possible, otherwise the paste will crack and crumple. This coating should never be worn longer than a few hours, for, as is the case with all complexion paints, enamel injures the skin, especially when frequently applied.

It is sometimes desirable for theatrical purposes to use a pigment for tracing out veins on a surface that has previously been coated with pearl white. The ingredients of bleu végétal pour les veines—vegetable blue for veins—employed for this purpose are: Venetian chalk, five hundred grams; Berlin blue, fifty grams; gum arabic, thirty grams. These are mixed with water to make a paste and are then fashioned into sticks.

Various face bleaches on the market contain corrosive sublimate as the principal or active constituent. Preparations of this nature are not to be countenanced. This formula shows the general make-up of this class: Mercuric bichloride, one grain; emulsion of bitter almond, twelve fluid ounces; tincture of benzoin, one fluid dram.

For a stage make-up, freckles are sometimes imitated. For this purpose a little burnt umber is worked up in a fatty base similar to that used for making complexion paints. The actor's face is peppered with this preparation.

Theatrical lining pencils are made of one ounce of stearine, one ounce of plumbago in fine powder, two ounces of prepared suet. The fats are melted, the plumbago added, and the mass is then run into glass molds.

Cosmetics of the Nails.—Discolored nails may be whitened by the application of a solution consisting of thirty grains of oxalic acid to one fluid ounce of rose water. Acetic acid or citric acid is sometimes substituted for oxalic acid in this preparation.

Still another preparation for whitening the nails is prepared according to the following formula: Tartaric acid, one dram; tincture of myrrh, one dram; cologne water, two drams; water, three ounces. The acid is dissolved in the water. The myrrh and cologne are mixed and added to the acid solution. The nails are dipped into this solution, wiped, and polished with a buffer.

In the case of brittle nails, a preparation that is often of benefit when rubbed on and about the nails consists of: Boric acid, one dram; salicylic acid, fifteen grains; lanolin, three drams; petrolatum up to one ounce.

In order to conceal white spots in the nail a polishing powder is used. Various formulas are offered for the polish. A simple one consists of: Zinc oxide, two hundred parts; carmine, two parts. Perfume with a few drops of oil of violets.

A nail polish commonly used consists of: Oleate of tin, powdered, four ounces; pumice stone, finely powdered, three ounces; oil of cinnamon, five drops; oil of bergamot, ten drops. These ingredients are carefully mixed and finely sifted.

A French formula for nail powder is composed of: Violet talcum powder, one-half ounce; boric acid, pulverized, one-half ounce; powdered starch, one-half ounce; tincture of carmine, fifteen drops.

The polish is sometimes made into "cakes" or "sticks." The following formula is suitable for this purpose: Putty powder, eight ounces; carmine, twenty grains. This mixture is scented and mixed with enough mucilage of tragacanth for the desired form. The "sticks" are piped on a pill machine.

A powder that is sometimes used with a little water, or mixed to a paste with oleic acid for a polishing "pomade" is prepared by mixing thoroughly: Magnesium carbonate, two ounces; powdered rouge, two ounces: white bole, ten ounces; lead carbonate, twelve and one-half ounces; prepared chalk, twenty-five ounces. A non-attritive polish has these ingredients: White wax, one ounce; cotton-seed oil, two ounces; carmine, five grains; oil of rose, five drops.

A preparation often employed to supplement the use of a polish is made of: Paraffin wax, one dram; chloroform, two drams; rose oil, three drops. A little is applied to the nail with a piece of chamois

or is used as an enamel by painting over the nail with a camel's hair brush. A so-called nail varnish is made according to this formula: Hard paraffin, one ounce; oil of citronella, ten drops; oil of lavender, one dram; acetone, sixteen ounces. The paraffin is shaved and dissolved in the acetone and the oils are added.

Sometimes a preparation for tinting the finger-tips is desired. This formula is suitable: Alkanet root, one-half ounce; alcohol, twelve ounces; rose water, four ounces. These ingredients are mixed and allowed to stand for a week. Ten drops of attar of rose are then added, and the preparation is shaken and filtered ready for use.

Hair Dyes and Hair Invigorators.—The physician is consulted by patients in regard to dermatitis produced by hair dyes far oftener than he is asked about the dye itself. For information about the latter, both men and women anxious for some reason to change the tint of the hair are prone to seek the advice of quack, hair-dresser, or beauty specialist. The more insistent the patient to undergo the process of rejuvenation, the more willing he is to take treatment at the hand of the charlatan that no medical man would dare to advise and that the individual himself would never consent to take from a regular practitioner.

Although the golden tint is not nearly so fashionable as it was some years ago, nevertheless there is still considerable demand for preparations that will lighten hair or at least keep fair hair from turning darker. The preparation most commonly advised under such circumstances is a solution of hydrogen peroxide. The strength of this application varies according to the original tint of the hair as well as according to the shade desired by the patient. The general belief that hair preparations containing hydrogen peroxide are absolutely harmless does not always hold. Obstinate dermatitis associated with falling of the hair following prolonged use of this bleach is reported.

Another application used to impart to hair a blonde tint consists of:

| | |
|---|---|
| Potass. permang. | grs lxxv. |
| Aq. dest. | ʒ iii. |

The hair is first shampooed with a weak solution of soda. It is then rinsed with warm water and carefully dried with a towel. The solution is first brushed over the hair and then thoroughly combed through the strands in order to impart an even tone. In the case of an original blonde shade this preparation will need frequent application since the effect quickly wears out.

Various secret preparations for imparting to hair a blonde tint are in the market. Like other cosmetics of this class, many are articles of foreign manufacture. One of these consists of a solution of one per cent. pyrogallol and one per cent. cupric chloride. This preparation may prove injurious.

Another blonde dye consists of two solutions: (a) 5.0 potassium permanganate and 95.0 distilled water. A brown bottle with ground stopper is used for this preparation. (b) 1.0 sodium hyposulphite and 25.0 distilled water. Before the dye is applied the hair is carefully washed with soda solution. After the hair has been rinsed and dried, the first solution is thoroughly distributed over it by means of a perfectly clean brush and comb. Whenever the skin is stained, the spot may be removed by moistening it with water, rubbing on a little soap, followed by the application of solution (b). In spite of Titian's approval some possessors of red hair cannot become resigned to the gift. To meet this condition a variety of dyes are compounded. One used to give a nanking yellow tint to soften the vividness of red, consists of a dissolved neutral salt of iron—acetate, sulphate, or chloride—followed by some alkaline solution; the latter may be lime water, sodium carbonate, or potassium carbonate. Again, red hair may be darkened. A preparation made up for this purpose consists of three and one-half grams of calcium saccharate, fifteen grams of glycerin, seven grams of jockey club, fifteen grams of rectified spirit, and sufficient water to make 300 c.c. The hair is sprayed daily with the dye, the color being distributed by thorough brushing.

But so variable is the standard of beauty that there are individuals who not having red hair, covet it. To meet this demand a vegetable hair dye of henna leaves is concocted. An infusion of the leaves (*Lawsonia inermis*) is made, strained, and evaporated to one in eight. To this are added two fluid ounces of alcohol. The mixture is then filtered. This dye is said to impart an auburn shade. The tint may be darkened by the addition of ammonia.

More common, however, is the demand for a dye for grayness that is not infrequently premature. A popular hair dye that has in many cases proved to be harmless, and very stable, is known under the trade name of Aureol. The preparation consists of two liquids. The first is a three per cent. solution of hydrogen peroxide. The second consists of one per cent. of menthol; three-tenths per cent. of amidophenol chlorate; and three-fifths per cent. of monoamidophenylamine. These ingredients are dissolved in fifty per cent. alcohol containing one-half per cent. of sodium sulphite. Equal parts of the two solutions are mixed for each application. The hair is first shampooed with soap or soda to remove all grease. After careful rinsing and partial drying of the hair, the dye is applied with a fine tooth comb. Even soap does not alter this color. Within a few hours the hair becomes dark brown. This color can be deepened by repeating the process.

If this preparation does not afford satisfactory results one can turn to the use of silver nitrate and pyrogallic acid. By varying the concentration of the silver solution, different shades may be produced at pleasure—from blonde to brown or dusky black. The pyrogallic solution is of constant strength.

Solution I.

| | | |
|---|---|---|
| ℞. | Acid pyrogallic | gr. viii. |
| | Spt. vini conc. | ʒ iiiss. |
| | Aq. dest. | ʒ xi. |

Solution II. Blonde to light brown.

| | | |
|---|---|---|
| ℞. | Argent. nit. | gr. xv. |
| | Aq. ammon. fort. | gr. xlv. |
| | Aq. dest. | ℥ i. |

Solution II. Brown.

| | | |
|---|---|---|
| ℞. | Argent. nit. | gr. xx. |
| | Aq. ammon. fort. | gtt. lxx. |
| | Aq. dest. | ʒ vii. |

Solution II. Dark brown to black.

| | | |
|---|---|---|
| ℞. | Argent. nit. | gr. xxxv. |
| | Aq. ammon. fort. | ʒ ii. |
| | Aq. dest. | ʒ vi. |

The pyrogallic solution is conveniently applied to the hair by means of a stiff tooth brush, care being taken not to dampen the scalp. When the hair is still damp, the silver solution is similarly applied with another brush, the liquid being allowed to reach to the skin.

Another dye consists of:

| | | |
|---|---|---|
| (*a*) | Silver nitrate | gr. 120 |
| | Copper nitrate | gr. 12 |

These salts are dissolved in two ounces of water, the ammonia is added with constant stirring until the precipitate that first appears is dissolved.

| | | |
|---|---|---|
| (*b*) | Pyrogallic acid | gr. 40 |
| | Acetic acid | fl. dr. 2 |
| | Alcohol | fl. dr. 12 |

If the skin becomes stained with the silver solution the spots may be removed by the use of potassium iodide.

In some instances the acetic acid is omitted. Copper sulphate offers a possible substitute for the nitrate since the use of silver nitrate alone is apt to impart a dull reddish tinge.

It is well to remember that dermatitis and even poisoning sometimes result from the use of pyrogallol.

Tomaszewski believes that: "Solutions which contain pyrogallic acid or p-phenylendiamin are to be unconditionally rejected as dyes for living human hair. Experiments by this investigator and Erdmann have shown that the irritating properties of p-phenylendiamin are increased by the addition of sulphur.

Paraphenylendiamin is a powerful blood poison and converts hemoglobin into acid hematin.

An advertised hair dye containing Indian ink suspended in a solution of gum arabic in thin quince mucilage is absolutely innocuous, but on the other hand it is not permanent.

A lead dye consists of: Litharge, one ounce; lime, freshly slaked, two ounces; starch, two ounces. These ingredients are finely powdered and are put perfectly dry into closely stoppered bottles. When used the powder is mixed with water into a thin paste. This may be applied by brush, fingers, or sponges. The hair is occasionally combed during the process in order to distribute the dye uniformly. The hair is kept damp for several hours—three or four—by swathing it in a moist cloth. Or, if preferred, an oiled silk cap may be worn. When the dyeing is complete the powder may be washed out of the hair with a warm water and soap shampoo. There is danger of lead poisoning from the use of this dye.

A tannin hair dye consists of two liquids:

| | | |
|---|---|---|
| (a) | Powdered gall-nuts | 400 grams. |
| | Water | 500 grams. |
| | Rose water | 500 grams. |

After the water containing the gall-nuts is boiled, it is strained through a fine-meshed cloth into the rose water. While it is hot it is poured into a clean glass bottle and immediately stoppered.

| | | |
|---|---|---|
| (b) | Silver nitrate | 150 grams. |
| | Water | 1 liter. |

Ammonia sufficient to redissolve the precipitate that is first formed.

This solution is placed in a dark bottle.

A walnut hair oil or dye is composed of:

| | |
|---|---|
| Green walnut shells | av. oz. 2. |
| Alum | av. oz. ½. |
| Olive oil | fl. oz. 4. |

These ingredients are heated together in a water bath until the water has entirely evaporated. The resulting product is then expressed, filtered, and perfumed.

A bismuth dye for hair or beard is compounded as follows: (a) Dissolve one hundred grams of metallic bismuth in a sufficient quantity of nitric acid. Treat this solution with a concentrated solution of ninety-seven grams of tartaric acid, then use a generous quantity of water for precipitation. Wash the precipitate with water until reaction with blue litmus is not strong. Carefully remove the precipitate from the filter paper and dissolve it in ammonia. In this solution dissolve seventy-five grams of purified sodium hyposulphite. Filter and treat with two to five per cent. of glycerin. It is now ready to bottle. The preparation contains about 5 per cent. of bismuth. This dye is applied once a day to hair or beard. Slowly a deep brown color develops.

If one wishes to be sure of the exact tint, it is well first to apply the dye to be used to hair that has been cut from the head. A patient should be warned, however, that the eye of even the unobservant can detect the artifice, however expert the technique.

In each instance, the hair before each dying must be cleansed from oil by soap or soda solution. The general method of application consists in brushing the single strands from point to root with a brush dipped in the dye. In this way the liquid finds its way into the interstices of the imbricated epithelial coat.

If the hair is found to be dry and lusterless after the coloring, oil is used to restore the gloss. In order to protect the skin from staining during the process the neck, temples, and forehead may be smeared with cold cream, sweet oil, or glycerin. A high-necked, close fitting dressing sack is a convenient garment to don at the time. The operator should wear rubber gloves.

Aside from the ordinary liquid dyes, powders are sometimes used to give to the hair a tint corresponding to the complexion, sometimes to make a marked contrast.

*Hair Tonics.*—In the field of hair restorers, hair tonics, and the like, a rich harvest awaits the quack and beauty specialist. If the preparations are harmless even though useless their sale may be overlooked. But unfortunately for the credulous many of these articles work positive harm.

In regard to local treatment of the hair it is necessary to recognize two conditions: First, excessive dryness, and second, excessive oiliness of scalp and hair. Again, dandruff claims much attention.

Out of the legion of articles recommended for these conditions a very few may be selected as examples of beneficial, useless, and harmful preparations.

A simple pomade beneficial in many cases of dry and itching scalp, falling hair, and dandruff, consists of Precipitated sulphur, one-half dram, and petrolatum, two ounces.

A simple antiseptic lotion for dandruff is composed of one dram of crude petroleum to an ounce of alcohol.

A preparation often advised in cases of dandruff and parasitic skin affections is: Unna's spiritus capillorum resorcin, twenty-five grams; castor oil, twenty-five; ninety-five per cent. spirit, seven hundred and fifty grams; eau de Cologne, two hundred grams.

Another lotion used for dandruff is:

| | |
|---|---|
| Bay rum | 5 ounces. |
| Tincture of cantharides | ¼ ounce. |
| Olive oil | 1 ounce. |

A liquid preparation that has proved beneficial for a dry itching scalp with falling hair and free from dandruff has these ingredients:

| | |
|---|---|
| Precipitated sulphur | 1 part. |
| Alcohol | 1 part. |
| Rose water | 5 parts. |
| Distilled water | 5 parts. |

A liquid hair tonic for dry scalp and falling hair has the following formula:

| | |
|---|---|
| Resorcin resublimed* | ½ dram. |
| Castor oil | 1 dram. |
| Spirit of wine | 5 ounces. |
| Balsam of Peru | 8 grains. |

* This is the only kind that should be used. The ordinary commercial resorcin is unsuitable as it sometimes causes discoloration of the hair.

So-called quinine hair tonics are much in vogue:

| | |
|---|---|
| Quinine sulphate | 20 grains. |
| Glycerin | 1 fluid ounce. |
| Cologne water | 2 fluid ounces. |
| Bay rum | 2 fluid ounces. |
| Rose water | 11 fluid ounces. |

The quinine is worked up in the glycerin and the other ingredients are added in the order given.

A very useful application for the scalp in case of excessive oiliness is made of the following ingredients: witch hazel, two ounces; alcohol, two ounces; distilled water, one ounce; resorcin (resublimed) ten grains.

An egg shampoo is in frequent demand: the following is a simple formula:

Yolk of one egg.
One pint of hot rain water.
One ounce of spirit of rosemary.

Beat thoroughly and use while warm.

A good hair-fluffing shampoo is compounded of:

| | |
|---|---|
| White soap | ½ bar. |
| Soft water | 1 pint. |
| Toilet water | 1 teaspoonful. |
| 3 eggs. | |

Shave the soap and boil in water to the consistence of jelly. When cool stir in the toilet water and the eggs well beaten.

A dry shampoo is often used in case of oily hair, and also to prevent the matting of hair during a long illness. This formula may be used:

| | |
|---|---|
| Rad. irid. florent | ʒ v. |
| Talc. venet | ʒ vii. ss. |
| Amyl. oryzæ | ʒ xii. ss. |
| Tr. moschi | gtt. viii. |
| Ol. citri, Ol. begam. | āā gtt. v. |
| Ol. aurant | gtt. ii. |

Analysis of a secret French preparation widely advertised as an antiseptic cosmetic for encouraging the growth of the hair shows the following ingredients:

| | |
|---|---|
| Quinine | 0.14 per cent. |
| Glycerin | 5.0 per cent. |
| Alcohol | 68.9 per cent. |
| Water | 25.0 per cent. |
| Peruvian balsam | 2.0 per cent. |

Inert scented substances with traces of lead.

This preparation is useless for the purpose claimed and may be injurious.

Another formula of this class for preventing dandruff and falling of the hair consists of: Extract of fresh orange peel in dilute alcohol; five per cent. of resorcin; three per cent. of Peruvian balsam. In many cases this preparation has proved injurious.

An onion solution for the beard which the manufacturers advertise is made from onion juice and which is declared to exert such a marvelous effect that by its use a luxuriant growth may be started on the chins of boys of fifteen, is merely dilute scented spirit colored with tincture of gentian.

A certain birch-oil balsam claimed to be a solution of the pith of South American birch and absolutely innocuous, is in reality an aqueous solution of lead acetate and a ten per cent. precipitate of a mixture of lead carbonate and sulphur. It cannot possibly be said to be harmless.

A preparation advertised to remedy baldness is merely dilute cologne water containing a little glycerin. It is practically useless as well as innocuous.

A secret shampoo powder has been found to be a scented mixture of 22.5 borax, 30 calcined soda, and 15 quillaya.

A brilliantine, also a secret preparation, for beautifying hair and beard consists of: seven parts of castor oil; fifty parts of almond oil; twenty-two parts of glycerin; two and one-half parts of jockey club extract; and one hundred and twenty-five parts of spirit. In spite of its somewhat elaborate construction, any simple sweet oil or fat would serve the same purpose. Or if one prefers—an excellent brilliantine consists of two drams of castor oil and six ounces of cologne water.

The formulas quoted here have been derived from many sources. Thus some are reproduced from the dermatologists' prescriptions; others were originally intended for the manufacturer of cosmetics.

The technology of cosmetics has been gradually advanced by the researches of chemists to fill its niche in the general scheme of the natural sciences. When it shall have been entirely cleared of the ancient dross of ignorance and superstition, and divorced from the marvelous and seductive claims of secret preparations, then will it assume its rightful place and accomplish its true mission as an independent branch of hygiene—a handmaiden of medicine.

EMMA E. WALKER.

**Costebelle.**—See *Hyères*.

**Coto.**—The bark of an unknown Bolivian tree of the family *Lauraceæ*. The writer of this article is probably the only botanist who has seen a botanical specimen from this tree. It was furnished him in La Paz, coming from the Indians of the lower La Paz River region, and consisted of a twig with several thick, coriaceous, lance-oblong leaves nearly a foot in length, and a fruit like a large acorn. It was evidently a species of Nectandra or of a closely allied genus. The specimen was forwarded but disappeared in transit.

The bark first appeared in market confounded with cinchona, but later with individual claims. It occurs in good-sized flattish pieces, four to twenty inches long by five to ten in width and one to two or three in thickness. It is of a deep red-brown color throughout, often with a violet or purple tinge to the brown. If, as is usual, the entire thickness is present, the outer surface is grayish, and little furrowed and fissured. The inner surface is very roughly striated or splintered, like the ends. The outer third is cellular, the remainder a mass of splintery bast tissue. The bark is very hard and heavy. It has a camphoraceous, aromatic odor, and two distinct elements are recognizable in the taste. It is immediately pungent, and very quickly peppery-biting in addition (see below, in the section on Paracoto).

Its volatile oil, resin, and *piperonylic acid* ($C_6H_3[O_2CH_2]COOH$) are all active, but the *cotoin* ($C_{22}H_{18}O_6$), which occurs as a yellow, crystalline powder, soluble in alcohol and slightly in water, is regarded as the important constituent and has been used alone. Tannin is not present.

In its own home, Coto possesses the highest reputation as a remedy, not only for diarrhea, but for dysentery, which is there one of the commonest and most fatal of diseases. It is an excellent stomachic and a very powerful intestinal stimulant, especially to the sympathetic system and to the functions of absorption, at the same time exerting a disinfectant action. It is of great value in controlling intestinal discharges. The fluid extract is the best preparation, the dose being ♏ v. to xx. (0.3–1.5). The powdered bark is very effective in equivalent doses. Cotoin is given in doses of gr. ss. to iij. (0.03–0.2). The genuine drug long since disappeared from our market, and it is greatly to be desired that so important and valuable an article should be rediscovered.

PARACOTO.—This is the bark of a tree apparently very closely related to the last and comes from the same locality. The bark is very similar in appearance, but is commonly a half thicker and in larger pieces, their curvature greater. It is more commonly deprived of the outer bark. When this is present it is rougher and browner. The best distinction is in the taste, which has a similar prompt pungency, but lacks the secondary peppery-biting element. It contains, in addition to the constituents of the last other than cotoin, *paracotoin* ($C_{19}H_{12}O_6$), which is yellow, crystalline, soluble in both water and alcohol, and acts similarly, but two or three times weaker; also *protocotoin* ($C_{16}H_{14}O_6$), yellow and crystalline, soluble in alcohol.

This bark acts similarly to the last, but is much weaker. It is also much cheaper, and was at one time very generally supplied in the United States when coto was called for. Like genuine coto, it has not been seen in the United States market for some years, though many spurious articles have been sold for it.

HENRY H. RUSBY.

**Cotton.**—See *Gossypium*.

**Cotugno, Domenico.**—Born in Ruvo, a city of the Kingdom of Naples, on December 3, 1736. At the age of seventeen he was sent by his parents to Naples, to study medicine; and only two years later—so it is stated by Dezeimeris—he was given the chair of surgery. Not long afterward he made a number of important discoveries relating to the internal ear; and he discovered the nerve which Scarpa later described under the name of the nasopalatine nerve.

Then, besides, he published some remarkable observations on sciatic neuralgia, on the immediate seat of the disease now known as smallpox, on galvanism, etc. At the age of twenty-five he was made Professor of Anatomy at the Royal University. His death occurred on October 6, 1818. His more important published works are the following: "De aquaeductibus auris humanæ internæ dissert. anatomica," Naples, 1760; "De ischiade nervosa commentarius," Naples, 1765; "De sedibus variolarum syntagma," Naples, 1769. In the first of the three books just mentioned will be found an account of his discovery of the lymph contained in the auditory labyrinth; and here, too, Cotugno gives the first reasonable explanation known of the uses to which the cochlea, vestibule, and semicircular canals are put.

A. H. B.

**Couch Grass.**—See *Triticum*.

**Cough.**—According to Webster, the English word cough (Lat., *tussis;* Fr., *la toux;* Ger., *der Husten*) is of Anglo-Saxon origin, and comes from the Dutch, *Kuch*—M. H. Ger., *kuchen*, to breathe; N. H. Ger., *kuchen*—whence the German term, *Keuchhusten*, for whooping-couph.

Cough is primarily a physiological act, protective in character. Under pathological circumstances it occurs as a symptom of local or general morbid conditions, and may be of mechanical or reflex origin. It is essentially a quick and forcible expiratory effort or series of such efforts, performed with complete or partial closure of the glottis, and is usually preceded by one or more deep inspirations. It has for its object the removal from the air passages of obstructive or irritating materials. It may be excited by irritation of the nerves when there is nothing to be extruded, and is most annoying and persistent under such circumstances. Its mechanism is thus described by Westbrook in the first edition of this Handbook:

"The *mechanism* of cough is as follows: When a foreign body or other irritant comes in contact with the peripheral expansion of the pneumogastric nerve (or of those with which it is intimately connected), impulses are generated which, travelling along the afferent fibers, are conducted to the respiratory center in the medulla oblongata. In the ganglion cells of this center the impulses are translated into others, which are conducted through the efferent fibers of certain cerebral and spinal nerves to the muscles of respiration, whose force they liberate.

"A study of the muscular relations of the thoracic walls shows that, while the muscles of *inspiration*—with the exception of the diaphragm and some small ones, *e.g.* the *levatores costarum*—are attached to, and act upon the upper ribs, the *expiratory* group make their principal traction upon the lower portions of the thorax. This is particularly the case with those auxiliary muscles which are brought into play in forced respiration. The expiratory group, in which we are especially interested, are, anteriorly and laterally, the *triangulares sterni* above, and the *recti*, *obliqui*, and *transversales abdominis* below.

"The action of the *triangularis* is simple, and does not require special notice. Arising from the sternum and xiphoid appendix, its fibers pass upward and outward, to be inserted into three or four of the costal cartilages. It reinforces the natural resilience of the cartilages, helping to restore them to the expiratory position. It may also have some effect in counteracting the displacing force of the muscles on the exterior of the chest, *e.g.* the *pectoralis minor*. The action of the *rectus* is equally simple. Its sole influence over the respiratory movements is to draw the sternum downward, and so to diminish the size of the anterior wall of the abdominal cavity. The action of the *obliqui* is more complicated. In the first place their posterior portions, which pass directly from the crest of the ilium to the ribs, exert an immediate and powerful downward traction upon the thoracic walls, not only diminishing the size of the lateral walls of the abdomen, but acting as *adductors* to the ribs, which have been put in the position of *abduction* during inspiration. In the second place, the more anterior portions have a crossed action, and make diagonal traction across the abdomen. This has been well described by Henle. It will be seen by reference to Figs. 1566 and 1567 that the upper portion of the *external*, and the middle portion of the *internal oblique* muscles of opposite sides, attached, as they both are, to the intervening sheath of the *rectus*, are

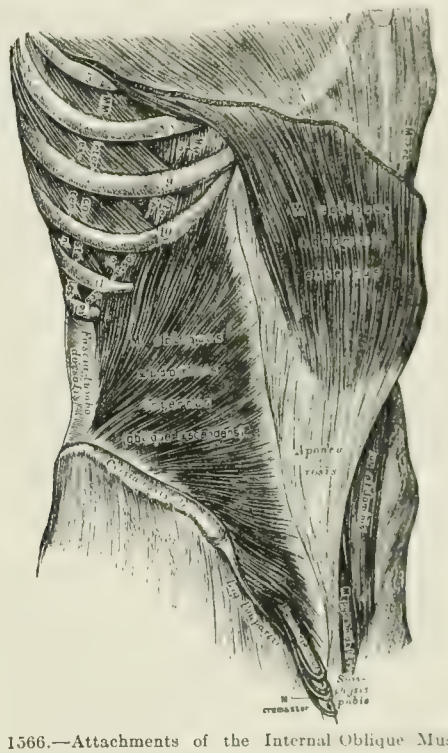

Fig. 1566.—Attachments of the Internal Oblique Muscle.

equivalent to one long diagonal muscle, which passes from the ribs on one side to the iliac crest on the other, and is capable, by its contraction, of drawing the ribs downward and inward, so as to contribute much toward the expiratory diminution of the thoracic cavity. It acts upon the abdomen as well. The function of the *transversalis* is equally important. Its middle portion is attached by a strong fascia to the transverse processes of the lumbar vertebræ; while the fibers below arise from the iliac crest and outer half of Poupart's ligament. Above, it arises from the inner surfaces of the costal cartilages.

"The fibers of this part of the muscle pass horizontally across the abdomen, and, by the mutual attachment of those from the opposite sides at the *linea alba*, one continuous muscle is formed, the contractions of which strongly adduct the lower costal cartilages and thus diminish the epigastric angle. The middle portion of the *transversalis* acts directly upon the abdominal wall. This is best illustrated in a horizontal section of the trunk just above the level of the umbilicus (see Fig. 1568).

"In its contraction the *transversalis* acts from the outer border of the *quadratus lumborum*, as that muscle fixes its tendon in the lumbar region. It tends, first, to draw the *linea alba* toward the fixed point; but the antagonism of the muscles of the opposite sides prevents lateral displacement, and simply

allows the anterior abdominal wall to approach the vertebral bodies, shortening the anteroposterior diameter. The muscular fibers intermediate between the anterior and posterior attachments, which, during distention of the abdomen, are sharply curved, become straightened during contraction and make strong lateral compression.

"The lower fibers of this muscle, when they contract, tighten the line across the inferior abdominal regions, and compress the intestines. The *transversalis*, then, by its contraction, first, assists in diminishing the size of the thorax; second, it contributes,

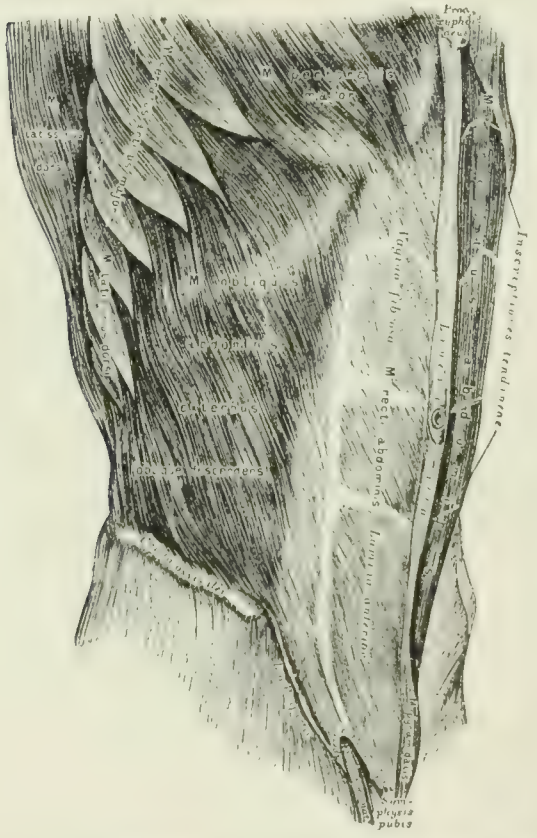

Fig. 1567.—Attachments of the Rectus and External Oblique Muscles.

more than any other muscle, toward the diminution of the abdominal cavity; and, third, it acts in a manner analogous to that of the lower portions of the oblique muscles.

"Posteriorly, the most important muscles of forced expiration are the *erectores spinæ*, *serrati postici*, and *quadratus lumborum*.

"The *erector spinæ* is easily divisible into an outer and an inner portion, viz., the *ileocostalis* and *longissimus dorsi*. The former is connected below, by means of the lumbar aponeurosis, to the iliac bone; above, to the angles of the six or seven lowest ribs. The *longissimus* is more complex, but the only part of it which is prominently concerned in the respiratory function consists of a number of digitations running from the lumbar aponeurosis below to eight or ten ribs above.

"When the *erector spinæ* contracts, it draws the ribs forcibly downward toward the pelvis, lessens the transverse and anteroposterior diameters of the thorax, and at the same time tends to shorten the perpendicular axis of the abdomen. Those accessory muscles which reinforce the divisions of the *erector spinæ* above, act upon the upper ribs, but their strength is far inferior to that of the *ileocostalis* and *longissimus dorsi* (Figs. 1569 and 1570).

"When these powerful muscles of expiration are spasmodically contracted in the act of coughing, their first effect is to adduct and depress the ribs, and by so doing diminish the size of the thorax in all its diameters. The adduction shortens the transverse diameter. The depression of the ribs and sternum shortens the anteroposterior diameter, and lessens the longitudinal axis of the general body cavity. But, as the abdominal walls yield only in the upward direction, and as the contents of the abdominal cavity are practically incompressible, its roof, the diaphragm, which is relaxed during expiration, must ascend and encroach upon the thoracic cavity, from which enough air escapes to compensate for the diminution in its size. The second effect of the expiratory contraction is to lessen the circumference of the abdomen. As the contents are incompressible, and as the sphincter muscles, by their contraction, prevent the escape of anything from the hollow viscera, the decrease in the transverse and anteroposterior dimensions of the abdomen must be compensated for by an increase in its long diameter—another factor in the production of the ascent of the diaphragm.

"This study of the action of the muscles during forced expiration will make plain the effects of coughing upon the lungs and other viscera. As has been already stated, the forcible expiration is preceded by a more or less deep inspiration, by which a large quantity of air is obtained for use in expelling the offending substance. The glottis is then partially closed, so as to narrow the route of exit and increase the friction of the escaping air against the mucous membrane of the larynx, trachea, etc. This is accompanied by the sudden and strong expiratory effort, during which the lower ribs are drawn quickly

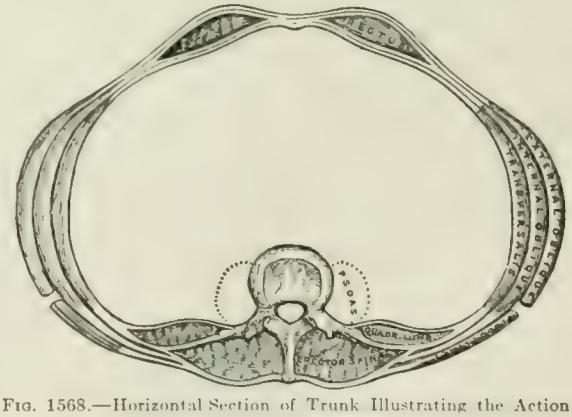

Fig. 1568.—Horizontal Section of Trunk Illustrating the Action of the Transversalis.

downward and inward, lessening the capacity of the lower portion of the thorax. The pressure upon the abdominal viscera drives them against the diaphragm, and pushes the floor of the thorax upward against the bases of the lungs. The lower lobes are then suddenly and violently pressed upon from all sides, and their contents driven in the direction of least resistance, viz., upward toward the trachea. If the displacement of the air is so sudden that the pressure in the trachea is greater than in the bronchial tubes of the upper lobes, the current will be reversed in the latter, and the superior and anterior parts of the lungs will be inflated; for the apices and anterior borders of the lungs are very little subject to the expiratory force, and expel their tidal and supplementary air properly only when the movements of the thorax are sufficiently deliberate to allow of an adjustment of pressure throughout. The forcible distention of

the apices is seen in those suffering from violent spasmodic cough, as in bronchitis, phthisis, and pertussis. During the paroxysms, the supraclavicular spaces are seen to bulge, sometimes to a very remarkable degree, partly from swelling of the large veins in those regions, but partly also from distention of the apices. The same thing can frequently be seen in the upper intercostal spaces, near the sternum.

"In acute bronchitis we find, as a result of increased expiratory efforts, both in breathing and in coughing, a temporary distention of the alveoli of the superior and anterior parts of the lungs, manifested by prominence

Fig. 1569.—Accessory Muscles of the Back.

and increased resonance on percussion. It is a temporary functional emphysema which subsides as the attack passes away."

Diagnosis.—The most important point for a physician to determine in relation to cough is its cause, and the diagnostic possibilities, therefore, should be carefully considered. Its semeiological relations are by no means confined to diseases of the nose, throat, and lungs, although it is most frequently indicative of disease somewhere in the respiratory tract.

It may be caused by the inhalation of irritants, as dust, smoke, fumes, gases, volatile oils, and, in susceptible subjects, certain pollens, and even by odors. Changes of temperature, and excessive dryness and excessive moisture of the atmosphere may give rise to cough without exciting visible inflammation. It may be provoked by undue heat or pungency of food or drink, or by minute drops of fluid entering the larynx. It may cause or be caused by vomiting, or, as in nervous diseases, cough and vomiting may be due to a common cause. Similarly, cough may provoke or be provoked by laryngeal, pharyngeal, esophageal, pulmonary, or gastric hemorrhage, or may be excited by blood from a nasal hemorrhage entering the larynx; or cough and hemorrhage may have a common origin. In such associations, therefore, care must be taken to examine the patient thoroughly, and to weigh duly all the facts of the case.

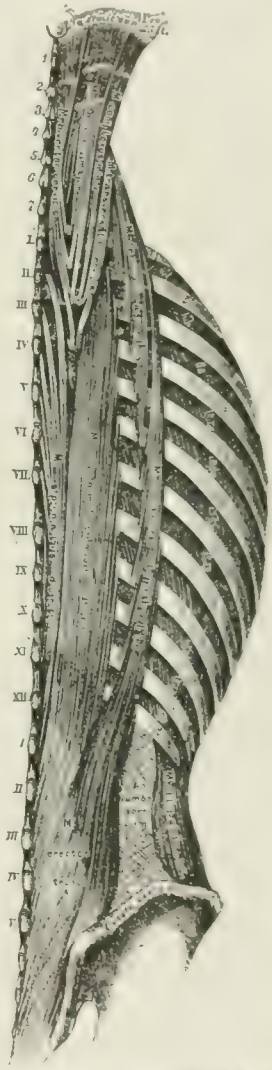

Fig. 1570.—Attachments of the Erector Spinæ et Mass. Ilio-costalis (Sacrolumbalis and Cervicalis Ascendens and Longissimus Dorsi.

Coughing may be reflex in origin, as from the irritation of teething; or it may be due to foreign bodies in the ear, or to the existence of a tumor, inflammation, or other irritative disturbance in any portion of the auditory apparatus; or to foreign bodies, polypi, enlarged turbinals, and other abnormities in the nasal cavities, or to adenoid vegetations in the nasopharynx. An elongated uvula; a relaxed palate; enlarged glands, or distended veins or keratosis at the base of the tongue, may give rise to cough by mechanical irritation of the epiglottis; while cysts or other tumors upon the latter structure may produce either direct or indirect irritation, or provoke spasmodic cough with symptoms of strangulation by becoming incarcerated between the ventricular bands or the vocal bands. Foreign bodies or tumors in any portion of the throat (including under this heading, pharynx, larynx, and esophagus), retropharyngeal abscess, a foreign body or a tumor in a bronchus, enlarged bronchial glands, a tumor or abscess of the thyroid gland, goiter, mediastinal tumor, aneurysm of the thoracic aorta or its early branches, or of the right carotid or right subclavian artery, the pressure of a distended lung apex in emphysema—any one of these may excite cough mechanically or by reflex irritation of the pneumogastric trunk or of one of its branches. Cough may likewise be due to cerebral disease, to tabes or other spinal affection, to neurasthenia, or to hysteria.

It may arise reflexly from irritation in any part of the digestive tract, including the liver, or may be due to congestion or edema, secondary to disease of the liver, of the kidney, or of the heart. Heart-cough is rarely recognized; and may be variously mistreated. Thus I have seen nose and pharynx badly scarred with the marks of unnecessary and futile electrocautery per-

formances, in cases in which a few drops of digitalis tincture or a small dose of spartein have caused long-standing cough to disappear. Its remote cause may be gout or alcoholism, and the most brilliant successes in treatment are sometimes due to the recognition of its gouty origin.

Cough occurs most frequently, however, as a symptom of inflammation, whether of the upper or lower respiratory tract: thus in sore throat of various localization, in epiglottitis, in laryngitis, in croup, in tracheitis, in bronchitis, in pneumonia (croupous or catarrhal), and in pleurisy; also in emphysema and in asthma. It is usually a marked feature in advanced cases of pulmonary tuberculosis, and sometimes in early cases, although in some instances pulmonary tuberculosis has been known to run its course from beginning to end with little or no cough.

The mere enumeration of these varied conditions, which, moreover, do not exhaust the list of possibilities, is sufficient to show that the cause of any cough must be carefully sought for both locally and in general conditions, and that unless both local and general examination has been made, no diagnosis can be considered beyond question. Laryngoscopy should never be neglected. Moreover, as in all other diagnoses, all of the facts in the case must be considered, and the decision based upon their association, rather than upon any individual symptom or sign.

Indications of greater or less significance may perhaps be given by the character of the cough. Thus a *ringing, metallic cough* is usually associated with pressure upon the pneumogastric nerve or its branches, and will accordingly be found in aneurysm, mediastinal tumor, and similar conditions. A cough of this character or a peculiar *hoarse, stridulous cough* without expectoration, and associated with paralysis of the left vocal band, raises a very strong suspicion of aneurysm even in cases in which all or most of the ordinary physical signs are lacking; and I have verified such diagnoses by fluoroscopy and by postmortem examination. A *muffled cough* suggests the presence of membrane within the larynx, and if the voice also be muffled, a high degree of probability is given to the diagnosis of membranous croup or diphtheria. The so-called *croupy cough*, or *crowing cough*, may be found not only in membranous croup and diphtheria, but in catarrhal and spasmodic laryngitis (false croup), and in laryngismus stridulus. The cough of asthma is of a hoarse, *wheezing* character. The *whoop* of pertussis is *sui generis*, and hence both characteristic and pathognomonic. Hysterical cough is often *staccato*, as is sometimes the cough of the insane, especially in the early stages of general paresis. It may, however, in hysterical subjects, assume almost any character, and the imitation of the cries of animals, more particularly the barking of a dog, or of the crowing of a rooster, is not uncommon. J. Solis Cohen has described an endemic of hysterical barking in a seminary for young women.

Cough is said to be *moist* when accompanied by more or less pronounced sounds of agitation of fluid in the air passages, and in such cases it is usually associated with expectoration; though in the case of pulmonary edema and other asthenic conditions, expectoration may be deficient. Cough is *dry* when not accompanied with expectoration, or when expectoration occurs only with difficulty and fluid sounds are absent. Cough is *productive* when it brings out a quantity of phlegm and ceases with such relief. It is unproductive when not so accompanied. Productive cough is sometimes termed *free*. The terms *prolonged* and *short, hard*, and *light*, are self-explanatory. Coughs of the foregoing characters are usually associated with inflammatory conditions in some portion of the air tract, and their character may be an indication of the character of the causative inflammation. By *hacking cough* is usually meant a short, dry, unproductive cough, caused by mechanical irritation, or of reflex origin. "Hawking" of mucus from the nose or nasopharynx into the throat should not be mistaken for cough. Sometimes cough is so severe as to cause the patient to become red in the face, and this is usually the case in spasmodic affections. In laryngismus stridulus and spasmodic croup, cyanosis may supervene. A cough is *suppressed* or *deficient* when, in diseases that are ordinarily accompanied by free coughing and expectoration, weakness of the patient deprives it of this character.

The characters of the matters expectorated sometimes give valuable information as to the cause of the cough, or as to the pathological process with which it is associated. This subject is fully treated of under the heading *Sputum*, elsewhere in this HANDBOOK. Here I shall but refer briefly to the yellowish, mucopurulent appearance of bronchitic sputum; the greenish color and unpleasant odor of the discharge in bronchorrhea; the dark, sometimes black, color of the sputum of pulmonary gangrene and its unmistakable putridity; the rusty sputum, prune-juice expectoration, and characteristic diplococci of acute lobar pneumonia; the sago-like, often black-spotted sputum of influenza with its characteristic bacilli; the greenish or nummular sputa of pulmonary tuberculosis with pathognomonic bacilli; the spirals and crystals of asthma; the membranous casts and Klebs-Loeffler bacilli of diphtheria—as illustrations. The entire absence of sputum suggests as the explanation of a cough, pleurisy, pulmonary tuberculosis, tumor or foreign body in the air passages, irritation of the epiglottis, pressure upon the pneumogastric nerve or its spinal accessory or recurrent laryngeal branch, congestion from cardiac debility, or some reflex origin.

Coughing may be attended with *accidents* of greater or less moment and severity. Thus in acute bronchitis the lodgment of a plug of mucus so that the expiratory current is blocked may produce a temporary dilatation or emphysema, while in chronic bronchitis the emphysema tends to become destructive and permanent. So in cough of any character the closure of the rima glottidis and the backward pressure may produce forcible distention of the apices, that may even lead to rupture of air sacs, of intervesicular or interlobular septa, or of blood-vessels. This is especially the case in spasmodic cough, as in the unproductive effort of phthisis, or in pertussis. During the paroxysm the supraclavicular spaces bulge, partly because the apices of the lungs are distended, partly because of turgescence of the veins. Circulatory disturbances are caused, mainly venous. As Westbrook pointed out, in ordinary breathing intrapulmonary pressure is slightly positive during the expiratory act. The forced expiration of cough causes sudden rise of pressure and arrests the current of blood in the large veins of the neck, chest, and abdomen, or may even reverse it. The blood from the right auricle and venæ cavæ is repelled upon the advancing blood. Thus the veins are overfilled in the stomach, the esophagus, the pharynx, and the larynx, in the pelvis, in the inferior hemorrhoidal branches, in the uterus, in the vagina, and in the bladder, and ruptures and hemorrhages may occur. In women, bloody, serous discharges from the vagina, and in many cases involuntary urination, may occur during paroxysms.

In some persons the eyes bulge or feel a painful pressure during coughing, and hemorrhage of the conjunctiva, and even of the retina, may occur. Not only blood-vessels but other structures may give way under certain conditions. Dr. Max J. Stern communicates to me the case of a physician, aged seventy years, whose clavicle was fractured by the sudden strain of cough; and I have personally observed rupture of the fibers or ligamentous attachments of some of the deeper muscles of the back, incapacitating the subject for a number of days.

The severity of a cough depends partly on the nature, partly on the location, of the irritation or inflammation exciting it. The epiglottis is quite sensitive to

irritation, and the reflex of cough readily producible. The superior compartment of the larynx (above the vocal bands) is much more tolerant, except that very slight irritation applied to a point on the meso-arytenoid fold will cause severe cough. On the whole, the greatest susceptibility is that of the mucous membrane of the lower larynx, trachea, and larger tubes, that is, below the vocal bands and above the smaller bronchi. At the latter, irritability diminishes, and the pulmonary parenchyma is still less sensitive. In pneumonia the cough is most largely due to the associated bronchitis; and, as already stated, coughing may be slight or absent in the early stage of pulmonary tuberculosis.

Treatment.—There is no treatment for cough; it may be restrained by the use of local or general sedatives, or stimulated by local or general excitation; but, as already stated, it is merely a symptom, and before it can be brought to an end its cause must be removed either through termination of the underlying disease in due course, or by surgical or medicinal intervention. It is often beneficial, even when caused by pathological conditions, preserving its physiological function as an expulsive mechanism. It is only when excessive or unproductive that it needs to be restrained. When insufficient, on the other hand, it may need to be stimulated. Attention, moreover, must be paid to the character of the expectoration, correction of which, whether by stimulation or restraint, may be the only treatment necessary to bring the cough within proper bounds.

Cough caused by local irritation above the epiglottis —such as an elongated uvula, or a relaxed palate, adenoid vegetations in the nasopharynx, nasal polypi, hypertrophied tonsils, or enlarged glands or vessels at the base of the tongue—is corrected by removal of the offending cause. The uvula may be partially amputated or treated with astringents or the electrocautery. The relaxed palate may be treated with astringents or by means of electric applications. Hypertrophied tonsils, adenoid vegetations, nasal polypi, should be excised, burned, or otherwise destroyed. Enlarged glands or varicose veins or keratoses at the base of the tongue should be destroyed, preferably by means of the electrocautery point.

The cough that sometimes accompanies acute faucial and pharyngeal inflammations is relieved by the treatment of the causative condition. Ice, ice cream, and other cold sedative applications are usually most grateful. In rare instances inhalation of the vapor of hot water, medicated with opium, cannabis indica, hops, and the like, is more soothing. Chronic pharyngitis may be accompanied with cough. In such cases astringent lozenges, such as guaiac, catechu, or rhatany, usually help to relieve it. In singers and speakers especially, there may be cough due to lack of secretions in the mouth and throat. A lozenge that I have found quite useful in such cases contains ♏ ij. of the fluid extract of pyrethrum, gr. $\frac{1}{60}$ pilocarpine hydrochloride, and ♏ ss. of oil of peppermint or an equivalent of menthol, or of camphor. It may be made up with chocolate, Irish moss, the artificial "marshmallow" used by confectioners, or powdered elm-bark. When smoking is the cause the habit must be abandoned.

Cough due to acute catarrhal laryngitis is not usually excessive, and needs no treatment other than that of the affection of which it is symptomatic; for example, inhalation of the vapor of warm water impregnated with compound tincture of benzoin and paregoric. A spray of adrenal solution is useful in early cases. The cough of chronic laryngitis requires, as a rule, some special attention; it is usually unproductive, and as it is a source of distress, and also mechanically prolongs the irritation and inflammation of the organ, may need to be restrained by sedatives. Of these, the bromides or opiates in very small doses are preferable. Certain synthetic preparations, as heroine and dionin are much lauded, but have no special advantage over morphine or codeine. The last named drug is to be preferred to morphine as it is less likely to produce an unfortunate habit. Small doses, about one-sixteenth to one-eighth grain of codeine or one-sixty-fourth to one-thirty-second grain of morphine, suffice. On the whole, however, paregoric seems the best of the opium group; gr. x. of strontium bromide and ♏ xv. of paregoric given with syrup of garlic or with mucilage of acacia three or four times a day, usually answers every purpose. A cold compress over the front of the neck is often useful in cases of subacute and chronic inflammations of the larynx, and incidentally helps to restrain cough. It is usually applied most conveniently at bedtime. Sprays of zinc phenolsulphonate (five grains to the fluid ounce of rosewater) and the like, or of wine of ipecac, may be used during the day. Morphine oleate (two per cent. in oleic acid) applied externally over the larynx, or endolaryngeally by sponge and carrier, sometimes has a useful sedative effect. When the cough of chronic laryngitis is obstinate and troublesome, and not overcome by the method applied to the treatment of the underlying affection, relief may sometimes be given by the administration of cimicifuga, gtt. x. or xv. of the fluid extract, three or four times a day. In cases dependent on congestion due to deficient cardiac action, digitalis, strophanthus, strychnine, sparteine, musk, camphor, or other cardiant, is usually efficient without special sedative treatment; but bromide or opium may be used with caution in these cases also. A small dose of morphine, say gr. $\frac{1}{60}$ to $\frac{1}{30}$, may be combined with some stimulating sialagogue or expectorant, as cubeb or pyrethrum, in a lozenge. As a rule, however, lozenges are not useful in checking cough, except when this is due to local conditions above the epiglottis. Lozenges or small tablets of epinephrin (suprarenalin) sometimes aid in restraining the cough of local congestive conditions.

In acute bronchitis, if the cough is easy and the expectoration free, no special indication is afforded for treatment. When the cough is hard and expectoration difficult, a stimulating, expectorant treatment is useful. Ammonium chloride stands at the head of drugs used for this purpose. Its taste, when disagreeable, may be covered with fluid extract of coca or with the powdered extract of licorice, in syrup of tolu or syrup of senega or garlic syrup. Paregoric may usefully be added to such a mixture when the cough partakes of an irritative character. In subacute and chronic bronchitis cough is usually due to insufficient fluidity of the secretions, so that they cannot be expelled readily. The terebinthinate and balsamic group of drugs is here of the greatest service. Eucalyptol and fluid extract of eucalyptus, oil of sandalwood, oleoresin of cubeb, turpentine, terebene, and terpine hydrate, are most frequently employed. Myrtol is perhaps better than any of the preceding. The general dose of the volatile oils is from gtt. x. to xv. in emulsion or capsule, or given upon sugar. Of terpine hydrate the usual dose is about gr. v. Minute doses of apomorphine or of pilocarpine or of fluid extract of pyrethrum, may be used with discretion. Inhalations of recent vapors of ammonium chloride from the "vaporole" or other convenient instrument are extremely useful; and terebene or eucalyptol may be used conjointly. When expectoration is too great and cough too frequent, aromatic sulphuric acid and codeine are among the drugs most useful. Tincture of belladonna, atropine sulphate, or extract of hyoscyamus, in small doses, or, when there is a distinctly neurotic element, scopolamine hydrobromide (gr. $\frac{1}{200}$ or less) may be cautiously used in cases of excessive secretion, or of spasmodic cough.

In pleurisy, cough becomes painful. Strapping of the ribs tends to restrain it, and, by restraining breath-

ing as well as cough, to relieve pain. When this does not suffice, codeine or other opium preparation should be given, when the pain is so great as to justify interference or to interfere with the patient's prospects of recovery; otherwise no interference is necessary. Hot applications, or ointments containing guaiacol, menthol, and birch oil well rubbed in externally over the seat of pain are often useful in restraining the irritation that produces cough. Sometimes a light blister acts happily.

In pneumonia it is unwise to try to check cough, as is so often done, by the administration of opium; especially unwise is the hypodermatic use of morphine. The greatest judgment is needed to determine whether or not to interfere, and, in the latter instance, the nature and character of the interference. Cough should be sufficient to permit of free expectoration of the matters contained in the bronchi. On the other hand, it should not be so frequent or so painful as to prevent the patient from sleeping or add to his physical or mental distress. Usually expectorant drugs, of which ammonium chloride and ammonium carbonate stand at the head, are given with good results upon the general progress of the case. My own resort to these agents, however, has greatly diminished both in extent and frequency, since general measures of all-round benefit have been available. Senega, squill, cimicifuga, and the like may be useful, though they should not be employed merely for a secondary influence upon the cough, if not otherwise called for. The inhalation of ethyl iodide also tends to render expectoration freer and to diminish irritation, and thus to keep the cough within due limit. Should it be necessary, as in rare instances it may be, to take active measures to restrain coughing, the cautious inhalation of chloroform is to be preferred. The chloroform is best carried over by means of oxygen passed through a wash bottle containing it. Nothing approaching general anesthesia should be produced. The relaxation of the vasomotor system is not dangerous in pneumonia, if not pushed to excess. Indeed, the administration of nitroglycerin sometimes relieves cough by diminishing pulmonary congestion and relieving the heart. Similarly the use of digitalis, camphor, musk, or pituitary (posterior lobe) preparations at the appropriate time, and cupping or venesection judiciously applied, while not to be prescribed merely for the relief of cough, include this in the sum of their effects. Nitrous oxide may also be used with caution. It is best given mixed with oxygen in the proportion of one part of the former to two of the latter, and may be inhaled after being passed through a wash bottle in the ordinary way. When inhalations are not available, spirit of chloroform, hydrocyanic acid, hyoscine hydrobromide, ammonium or sodium bromide, and if necessary, codeine, may be cautiously employed by internal administration. Some physicians administer tartar emetic in doses of gr. $\frac{1}{20}$ or less to an adult to promote secretion and thus to lessen cough. I have never used it for this purpose. Flaxseed poultices and other hot applications tend to allay cough; and the same thing is said of cold compresses and icebags.

As a rule, however, when pneumonia patients are treated in the open air or in a large, cold, well-ventilated room, cough is not distressing and needs little or no special attention. In cases treated routinely with creosote carbonate, as also in those treated with massive intramuscular injections of quinine and urea hydrochloride, the general amelioration frequently extends to cough also. Similarly in cases treated with bacterial products (pneumococcic and mixed bacterins, "vaccines," toxic filtrates, etc.) the general relief, when the method is successful, obviates the necessity for medication directed to the special symptom. In the catarrhal pneumonia or capillary bronchitis of children inhalations of medicated steam or the use of a croup-tent, or croup-kettle to produce a moist atmosphere, in which also benzoin or eucalyptus may be volatilized, is often useful. In some cases vomiting must be induced to clear the air passages.

In asthenic conditions, as hypostatic pneumonia, pulmonary edema, capillary bronchitis of the old and debilitated, and sometimes in infants, cough is deficient. It then needs to be stimulated. Opium and depressants should be avoided, and such agents as strychnine, turpentine, digitalis, mustard oil well guarded, musk, ammonium carbonate or aromatic spirit of ammonia, quinine, hydrogen dioxide, and oxygen should be used.

The cough of pulmonary tuberculosis requires very skilful management. The tendency of both patients and physicians is to try to suppress it. This is a mistake, as it is of the utmost importance for the patient to free the air passages from the morbid accumulations. The cough may be regulated, but no effort should be made to bring it to an end, except naturally as an indication of progress toward recovery. The inhalation of compressed air, especially if conjoined with expiration into rarefied air, tends at first to increase cough by facilitating the expectoration of matters otherwise retained in unventilated regions of the lung. Later the diminution in the quantity of morbid product tends to reduce the cough. The cough is often favorably influenced by the other features of the hygienic treatment, especially by hydrotherapeutic procedures, of which the simplest is the morning cold (or alternate hot and cold) sponge or shower bath. All medicaments advocated for use in tuberculosis, whether by the laity, by quacks, by physicians (or by those who belong partly in all these classes and wholly in none), number among their alleged virtues the lessening of cough. This is, in fact, true of creosote and its derivatives and congeners, and of the balsamics and terebinthinates, of which latter cinnamic acid (sodium cinnamate), Peruvian balsam, eucalyptol, terebene, and myrtol are the best. Guaiacol cinnamate is a useful compound. Ethyl iodide, creosote, chloroform, bromoform, oil of peppermint, and the terebinthinates and volatile oils in general are useful by inhalation. Singly or combined in various proportions they may be inhaled from the vial, or from the sponge of Dr. Burney Yeo's perforated zinc respirator. The latter is quite useful too, at times, in pneumonia.

In certain forms of irritative tracheal or laryngeal cough, associated perhaps with a tendency to laryngeal spasm, and especially in cases of luetic origin, the steam-atomizer charged with an iodine preparation (*e.g.* ten or twenty minims of Lugol's solution to the fluidounce of water) used two or three times daily for five to ten minutes at a time, frequently palliates. In fetid bronchorrhea the iodine inhalation or a weak aqueous solution (one to four grains to the fluidounce) of potassium permanganate, similarly used, produces surprisingly great relief.

Stomach-cough, liver-cough, etc., and the cough of rheumatic or gouty bronchitis, laryngitis, or pharyngitis, must be overcome by appropriate constitutional treatment; but strontium bromide may usefully form a part of that treatment, and often helps to allay the irritation that produces cough.

Whooping-cough is often unamenable to medicinal treatment, and the best remedy is to send the patient, if possible, to the seashore, to be kept in the open air as many hours out of the twenty-four as the sun shines, and as otherwise may be advisable. Among palliative remedies inhalations of various kinds have been recommended. The vapors produced in the manufacture of coal gas, inhaled at the gas works, have a popular reputation not wholly undeserved. Ozone, hydrogen dioxide, hydrofluoric acid, chloroform, ethyl iodide, and bromoform, have all been highly recommended by competent observers, and are

doubtless useful in individual cases. The vaporization of menthol or eucalyptol, or both, day and night in the rooms occupied by the patient, and in sufficient quantity to be easily discernible upon entering the room from the outer air, is useful. Creolin, carbolic acid, and various coal-tar and coal-oil products under proprietary names, have been advised for use in a similar manner, and all of them have proved beneficial in a certain number of cases. Toxic effects may be produced by the absorption of such drugs, and the same care must be observed as in the case of internal administration. Formaldehyde solution (formalin) has been advised for inhalation, well diluted, from an inhaler on the plan of a Wolff bottle. The terebinthinates, of which eucalyptol is best, may be dropped on a sponge suspended like a locket from a tape about the child's neck, or held over the nose and mouth by the Yeo respirator, and thus the respired air be continuously medicated.

As to internal medication, the collateral bronchitis should be treated on general principles, and to allay cough, bromoform seems on the whole the most useful of all the drugs that from time to time have been recommended, of which the name is legion. To a child two years old gtt. ij. bromoform in glycerin and sherry wine, or in aromatic elixir, may be given every two, three, or four hours, as may seem necessary. In every instance, however, the dose must be adjusted to the age and susceptibility of the patient and the severity of the case. Hydrogen dioxide has, in my hands, proved useful in doses of from ℥ xx. to lx., diluted with glycerin and water, and given every third or fourth hour. Sulphurous acid, sodium hyposulphite, and Hope's nitrous acid mixture seem also to have some usefulness. Sprays of adrenalin have been advised. Vaccine and serum treatment have recently been introduced.

Laryngismus stridulus is usually an accompaniment of rachitis, the constitutional treatment for which must be instituted. In addition, amyl nitrite inhalations may be used to relax the spasm, and care is necessary to guard against strangulation of the child by incarceration of the epiglottis. Nitroglycerin or sodium nitrite given internally for prolonged periods, in doses appropriate to the age of the patient, sometimes has a beneficial effect in diminishing the frequency and severity of the paroxysm.

Tumors and foreign bodies are to be removed if possible.

Retropharyngeal abscess is to be treated surgically, and the associated cough will disappear. Enlarged bronchial glands are not as yet susceptible to direct treatment, but crystallized calcium chloride, given internally in some suitable vehicle, in doses of gr. x. or xv. three or four times daily for a child of seven or eight years, and proportionately larger doses for older persons, often exerts a beneficial influence upon glandular enlargements in general. So, too, the so-called alterative treatment with preparations of iodine, of arsenic, and of mercury, is often useful. When glandular enlargements are due to syphilis, tuberculosis, or other recognizable cause, that will furnish the indication for treatment.

The cough of asthma is rather to be encouraged than diminished, as free expectoration will sometimes assist in cutting short the paroxysm. Otherwise the treatment is that for the underlying condition, and need not here be discussed. The cough of hysteria can be controlled only by psychic influence, the physical medium of which may be an electric application, a blister, or other means, according to the individuality of the patient and of the physician. In my own observation painful electric applications to the larynx or over it have been the most successful; though these should be made only with great caution, and never by those inexperienced in the use of electricity in the neighborhood of the pneumogastric nerve.

SOLOMON SOLIS COHEN.

**Counterirritation.**—This is a remedial measure the object of which is to produce a congestion of the vessels at the surface of the body for the purpose of relieving a disturbance of some remote tissue or organ.

The principle of counterirritation is followed in many therapeutic methods of a general character, all of which relieve internal, or more or less localized, congestions. Those best known are hot baths, steam baths, hot foot baths, heat to the extremities, bloodletting, etc. These general methods, however, are not known as counterirritants; the term is restricted to such as are more local in their action and which are employed to accomplish a definite object. For this purpose various irritant drugs are utilized, as well as the actual cautery, dry-cupping, and other similar means which cause a local irritation.

Counterirritation is resorted to for three purposes: to relieve pain, to lessen congestion and inflammation of deep-seated organs, and to promote the absorption of the products of inflammation. In selecting the particular counterirritant by means of which it is hoped to attain these ends, the degree to which it acts must be the guide for its employment. If the trouble is of recent origin, or if the organ is simply a little congested, a mild counterirritation will usually prove sufficient; but if the disturbance is of longer duration and especially if structural changes have begun, then a more severe and prolonged effect is required. The immediate effect of rubefacients is much greater than that of vesication and other more active irritants, but the remote effect is much less. For this reason they are selected at the onset of pleurisy, bronchitis, pulmonary and renal congestion, neuralgias, colic, and gastric pains; the extensive reddening of the surface in the neighborhood of the part affected affording immediate relief. On the other hand, when the inflammation is established, as in advanced bronchitis, pleurisy, endocarditis, peritonitis, sciatica, inflamed joints, and other serious affections, vesicants, pustulants, and the actual cautery produce a prolonged and more effective counterirritation.

Although the beneficial effect of counterirritation is very evident, the manner in which it is produced is as yet undetermined. It has been thought to depend upon a direct vascular connection between the affected organ and the adjacent skin surface. This explanation is applicable to superficial and intercostal neuralgias, to inflammation of the costal pleura, and to many joint affections, when there is a blood supply common to both parts; but it is not sufficient to explain the relief afforded to deeper parts which have an independent circulation. The more recent and probably the more correct explanation is that which looks to the sensitiveness of the cutaneous nerves and their reflex action upon the deeper parts. The activity of the superficial reflexes is evident to all, and experimental work has shown that a similar influence is exerted on the deeper organs, as where an irritant to the skin over the kidneys causes a contraction of the renal vessels, or where, in an exposed pia mater, the vessels are similarly affected by irritating the scalp. Further evidence of this relation between the deeper parts and the surface is furnished by the many reflected pains that arise when the organs are diseased. Each segment of the spinal cord has sensory nerves arising in the deep organs and upon the surface. As an affected organ is reflected to the surface, so an irritation to the surface may readily influence the same organ. Starting from this explanation as a basis, we may maintain that with a careful mapping out of the skin areas most intimately associated with the various organs it will at once be possible to employ counterirritants in a more rational and effective manner.

The irritation produced by counterirritants varies in degree, and the difference is expressed by the terms rubefaction, vesication, and pustulation, according as they simply redden the skin or produce a blister or a

pustular eruption. These terms do not imply sharply defined groups, as one may merge into the other, and a single drug may cause one or all of these effects according to the strength of the preparation or the length of time it is applied.

Rubefacients are such as produce a reddening and congestion of the skin, the vessels becoming dilated and the supply of blood increased. The effect is immediate, but of short duration, as it rapidly disappears when the irritation is removed. When the application is prolonged it causes a severe inflammation of the skin which may result in vesication or ulceration. For this reason rubefacients require to be applied with some care to children and others whose skin is thin and sensitive, as the irritation may be unnecessarily severe. The same caution is necessary when they are applied to the skin of those who are unconscious or in whom the sense of pain is impaired.

Mustard, capsicum, ammonia, turpentine, camphor, and iodine are the best known of this group.

The *actual cautery* is particularly serviceable, as by its careful use the physician may establish any degree of counterirritation. By simply passing the heated iron over the surface of the skin, but not in actual contact with it, he may produce the mildest rubefaction; and if a more severe effect is required, he has only to bring the point of the cautery lightly and quickly in contact with the skin. Very little experience is required to enable one to produce almost any degree of counterirritation, and to control the action of the heated instrument.

*Dry-cupping* is a means of counterirritation that is still frequently resorted to. It produces a rapid and intense rubefaction which persists for some time.

Vesicants.—In vesication there is a deeper and more severe inflammation of the skin which results in an effusion of serum beneath the cuticle. If the application is prolonged the effusion of serum may be very great. The counterirritation may also be prolonged for days or weeks, by the application of irritating substances to the denuded surface, after the effused fluid has been removed. In selecting a site for the application of a vesicant it is advisable to avoid any bony prominence, as there may be trouble afterward as regards the healing of the spot. A depressant effect is apt to accompany blistering, and this may become a serious affair if the patient is weak or if the blistered surface is very extensive.

*Cantharides* is the one drug that is almost alone used for this purpose. The cerate, spread in the form of a plaster, is the preparation generally employed. It is slow in its action and requires to be kept applied for about eight hours. To increase its action, camphor, ether, acetic acid, and the powdered drug may be applied to the surface of the plaster. Hot linseed poultices may also be applied after removal to promote the effusion of its serum. Some caution is necessary during the employment of cantharides, on account of the liability of its being absorbed and exerting an irritant effect upon the kidney. If there is any tendency to kidney disease this caution is particularly required. Acetic acid is a very efficient solvent of cantharidin, and the liquor epispasticus of the British Pharmacopœia possesses a much more rapid action than any other preparation, one application being generally sufficient to cause a blister in the course of an hour. Cantharidal collodion is also an effective preparation, but less rapid in its action than the above.

*Ammonia* is employed as a vesicant, but it is less effective than cantharides and very painful. A piece of lint is saturated with the water of ammonia and kept in contact with the part.

*Hydrochloric acid* is also sometimes used, the pure acid being applied to the surface.

Pustulants.—Croton oil and tartrated antimony are typical representatives of this group. Their application results in a pustular eruption accompanied by much inflammatory action. The course of the eruption is similar to that of the rash of smallpox, the formation of pus persisting for several days and leaving the part deeply pitted and scarred. On account of the severe effect which they produce, pustulants should not be extensively applied, nor should they be applied to any exposed part for fear of causing disfigurement.

*Croton oil* is the pustulant generally employed. When pure the oil is too strong to be used undiluted, and olive oil or spirit is added until the croton oil is reduced one-half.

*Tartar emetic* in the form of an ointment, one part to four, was formerly much used. It is now rarely employed, as its action is slow, and severe depression may result from absorption of the drug.

Setons and Issues.—Formerly a prolonged counterirritant effect was produced by the use of setons and issues. These are not resorted to at the present day, although an occasional reference is made to their value by the older surgeons.

*Setons* were artificial sinuses formed by pinching a fold of skin and subcutaneous tissue, and, with the aid of a seton needle, passing through it one or more strands of silk, cotton, hair, or some such material. This was left in place and each day moved back and forth. The object was to promote suppuration, and, in order to increase the irritation, some caustic preparation was often applied to the material.

*Issues* were wounds artificially produced and maintained for the purpose of securing a continuous discharge of pus. When a small issue was desired, the wound was simply an incision made by a knife. When a more marked effect was required, caustics and the moxa were resorted to to destroy the part. Various methods were adopted to maintain the discharge, such as the introduction of peas and beads, irritating drugs, and caustics.

Beaumont Small.

**Cowper's Glands.**—Anatomy.—Cowper's glands consist of two small rounded, lobulated bodies situated on either side of the membranous urethra between the anterior and posterior layers of the triangular ligament. These glands are composed of several lobes held together by fibrous tissue. Each lobule consists of several acini lined with columnar epithelium, which open into a duct which joins those of other lobules and forms the excretory duct. This excretory duct is about an inch in length and extends forward under the mucous membrane, opening by a small orifice on the floor of the bulbous urethra.

Cowperitis.—Urethral infection may extend into Cowper's gland and produce either acute or chronic inflammation. Such inflammation is less frequent than are prostatitis and seminal vesiculitis, but its possibility should be remembered in chronic recurrent infections when the usual remedies fail.

*Symptoms.*—The symptoms of acute cowperitis are pain, swelling, throbbing, and a feeling of tension caused by the swelling within the inelastic investment of the gland. There may be considerable constitutional disturbance.

The chronic inflammation usually produces no symptoms pointing toward involvement of this gland.

*Diagnosis.*—The diagnosis is readily made from the above symptoms with a tenderness and swelling within the membranous urethra and later more extensive swelling and reddening of the subpubic and perineal tissues as well as scrotum. When well established the inflammation often proceeds to pus formation.

Chronic infection of Cowper's gland is less easily diagnosed and may be overlooked entirely unless the examination be conducted with this particular affection in mind.

The urethra and bladder should be irrigated with a boric acid or physiological salt solution to wash away urethral pus. The patient is placed in a dorsal lithotomy position. Having on a rubber glove, the surgeon introduces his finger into the rectum only far enough to press from behind forward under the symphysis pubis on each side of the urethra. The glands may be felt as small masses against the bony structures between the triangular ligaments. Remembering the course of the excretory duct of Cowper's gland these masses should be massaged from behind forward. The secretion may be emptied into the urethra and then expressed by gentle pressure, or if the amount is too small to appear thus as a discharge,

Fig. 1571.—Cowperitis with Large Abscess of the Gland.

the boric acid solution in the bladder may be voided and examined for pus cells. It is needless to caution against massaging the prostate gland or any of the urethra except the membranous portion when making a differential diagnosis.

In routine examinations of the prostate gland the finger should feel for Cowper's glands both to become familiar with the normal glands as well as to detect the diseased ones. If the forefinger is passed into the rectum and the thumb held over the perineum a very satisfactory examination of Cowper's gland may be made.

If the urethral inflammation is slight an endoscopic examination should be done to determine the condition of the orifices of the excretory ducts. If an assistant press upon the gland while this orifice is being viewed the character and amount of the secretion may be seen and transferred to a slide and stained for pus and microorganisms.

*Treatment.*—In cases of acute cowperitis the patient should remain quiet and take hot sitz baths twice daily. Hot fomentations should be applied to the perineum. Gonococcic vaccine in doses ranging from 40 to 100 million every other day or gonococcic phylacogen in ½ to 1 c.c. doses every other day will frequently effect a satisfactory cure. If no satisfactory result is obtained after ten days of this treatment, or earlier if pus formation can be detected, an incision should be made and the cavity drained. Other inflammatory affections such as urethritis, prostatitis, and seminal vesiculitis should be treated simultaneously. If the abscess in Cowper's gland is not incised it may open into the urethra and produce infiltration of urine and sloughing, which may finally result in the formation of a fistula.

Chronic inflammation of Cowper's gland may prove resistant to treatment because of the inaccessibility of the gland. Massage of the gland every other day, and adequate treatment of all other lesions with vaccines, phylacogen in small doses, and hot applications are the best measures. If in spite of the application of these remedies the enlargement and inflammation continue, and the prostate gland and seminal vesicles seem normal, Cowper's gland should be incised and drained, or preferably excised. This latter measure is only occasionally necessary.

Unfortunately other important structures such as the prostate gland and seminal vesicles are usually infected along with Cowper's glands so that to treat them alone regardless of the method, will probably not effect a cure. E. G. Ballenger.

**Cowper, William.**—Born in Hampshire County, England, in 1666. He practised surgery in London. His reputation, however, rests upon the work which he did as an anatomist, and more particularly upon the fact that the discovery (announced in 1702) of certain urethral glands—now for more than two centuries known and described as Cowper's glands—is universally credited to him. Both Dezeimeris and the author of the article on "Anatomy" in the *Encyclopædia Britannica* say that the existence of these glands had already previously (1684) been noted by Méry. Both of these writers also call attention to an act of plagiarism of which Cowper appears to have been guilty. "He stained a reputation otherwise good by publishing as his own the engravings of G. Bidloo, a Dutch anatomist." He died on March 8, 1709.

The most important of his published writings bear the following titles: "The Anatomy of Human Bodies," Oxford, 1698; and "Descriptio glandularum ductumque earum excretoriorum," London, 1702. The first of these contains 114 figures, only seven of which belong to Cowper; all but one or two of the remaining 107 having been taken from Bidloo's *Anatomia corporis humani* (Amsterdam, 1685).

A. H. B.

**Cowpox.**—See *Vaccinia*.

**Coxalgia, Hipjoint Disease.**—See *Arthritis*.

**Coxa Valga.**—This is a deformity in which, as opposed to coxa vara, the angle of the neck of the femur is abnormally great.

As compared to coxa vara it is rare and of slight importance. It is most often congenital, but it may appear in bones that have been relieved from weight bearing, as after amputation, or paralysis of an extremity. Injury is also a possible cause. It would appear that many of the reported cases are misinterpretations of *x*-ray pictures in which inward or outward rotation of the limb has distorted the shadow.

An angle of 140° is considered to be within the normal limit. If the elevation were greater the range of adduction might be sufficiently restricted to cause disability. If this limitation resisted manipulative treatment, the normal relation should be restored by osteotomy. Royal Whitman.

**Coxa Vara.**—*Synonym:* Incurvation or depression of the neck of the femur.

The neck of the normal femur projects slightly forward, and upward from the shaft to form an angle

of about 125° (Fig. 1573, a). In childhood the angle is somewhat greater and in later years it may be somewhat less than this, variations between 110° and 140° being within the normal limit.

When the neck of the femur is depressed to a degree to cause disability, it is called coxa vara. This name, although not especially distinctive, serves to class the distortion, in its more restricted sense, with genu valgum and genu varum in the group of so-called static deformities of the lower extremity that usually appear at two periods of life; in early childhood as the direct result of rachitis, and in adolescence, the period of rapid growth, when the unstable tissues are often subjected to disproportionate strain.

Genu valgum and genu varum are most common in childhood, and the diagnosis is of course obvious.

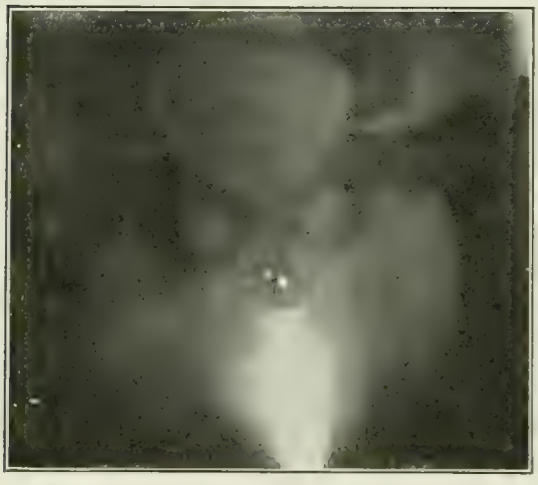

Fig. 1572.—Coxa Vara.

Coxa vara, on the other hand, is essentially a disability of later childhood or adolescence, and as the deformity is concealed from view, the diagnosis must be made from the physical signs. For this reason coxa vara, as an isolated deformity, was not identified until 1889, when E. Müller obtained a specimen by excision (*Beitr. zur klin. Chir.*, 1889, Bd. 4). As an incident of general rachitis, however, it had been described previously by Fiorani. (*Gaz. degli Ospitali*, Nos. 15 and 17, 1881.)

Etiology.—*X*-ray examinations of rachitic children indicate that coxa vara of slight degree is not uncommon, the depression being either direct (Fig. 1573,b) or indirect (Fig. 1573,c) due to outward bowing of the shaft. In such instances it is usually bilateral and it rarely attracts attention clinically, possibly because its symptoms are masked by the more obvious distortions of the extremities that usually accompany it.

As a lessened angle subjects the neck of the femur to greater strain, such slight deformity doubtless serves as a predisposing cause of disability in later years. In this sense the common form of coxa vara may be classed as a rachitic deformity, many of the patients presenting a history or physical signs of previous rachitis, although active or so-called late rachitis is extremely uncommon. The weakness of adolescence and general disturbances of growth and nutrition are also predisposing causes, certain of the subjects being fat and sometimes overgrown or showing evidences of so-called infantilism.

Injury is the most important exciting cause both in predisposed and in normal subjects. In the latter instance it should of course be classed as a fracture and treated as such, but as the diagnosis of fracture is rarely made it is usually for the resulting deformity, rather than for the immediate injury, that treatment is sought.

Coxa vara is in rare instances an isolated congenital distortion, and the neck of the congenitally dislocated femur is often shortened and depressed.

Finally, it is of course evident that it might be one of a series of distortions, caused by osteomalacia, osteitis deformans, and the like, or that it might be the result of local destructive disease. Incidental deformities from such causes, however, should not be classed with coxa vara, which is in most instances a simple deformity in the sense that it may be remedied by operative treatment.

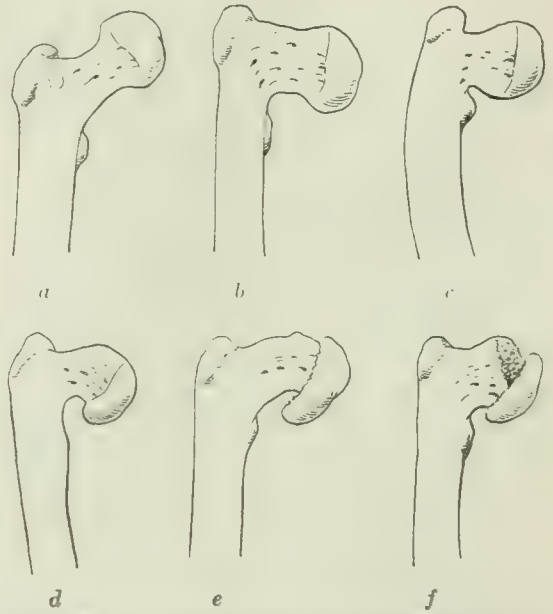


Fig. 1573.—Coxa Vara. *a*, The normal angle of the femur; *b*, coxa vara; *c*, coxa vara due to bending of the shaft of the femur—a type found in rachitic children; *d*, coxa vara with downward displacement of the head—a deformity found in cases of long standing; *e*, epiphyseal fracture combined with a slight degree of coxa vara; *f*, epiphyseal fracture. Figures *e* and *f* illustrate the common form of the so-called epiphyseal coxa vara.

Coxa vara is usually a depression of the neck as a whole. There is another form, however, in which the deformity is most marked at the junction of the head and neck (Fig. 1573,d). This is called epiphyseal as distinguished from the ordinary or cervical form. The two may be combined or the neck may retain its normal angle while the head is displaced downward and backward, a form of epiphyseal fracture (Fig. 1573,f).

Physical Signs and Symptoms.—The nature of the symptoms of the ordinary unilateral form is explained by the physical effects of the deformity. The neck of the femur is depressed, and it is usually twisted somewhat backward in its relation to the shaft, following the line of least resistance. Thus the limb is actually shortened and is rotated outward; the trochanter is elevated above Nélaton's line, its prominence is increased, and it is displaced somewhat forward toward the anterior superior spine in compensation for the loss of the normal forward projection of its neck.

The direct effect of the distortion is limitation of the normal range of motion. Abduction is checked by the tension upon the lower border of the capsule, by the adaptive shortening of the adductor muscles, and by the direct contact of the neck of the femur with the

upper border of the acetabulum (Fig. 1574). Inward rotation and flexion are limited because of the backward displacement of the neck, but the range of extension is not restricted and it may even be increased.

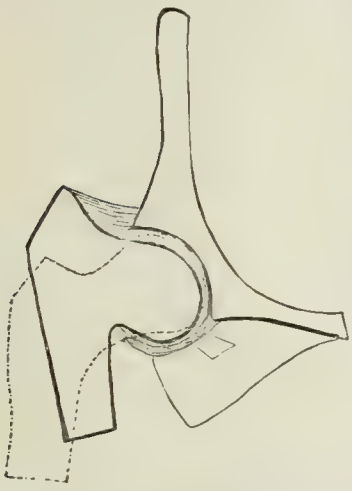

Fig. 1574.—Cross-section of the Pelvis and the Deformed Femur. A scheme to show the effect of the deformity in limiting abduction of the limb. The dotted outline shows the normal relation.

In rare instances the depression of the neck of the femur may be directly downward, in which case the range of motion is but little affected except in abduction; or the distortion may be downward and forward, when extension and outward rotation are limited in the place of flexion and inward rotation. These cases are, however, exceptional, and they are practically never seen in the adolescent type of deformity.

The most noticeable symptom of coxa vara is a persistent limp, due primarily to the shortening of the limb caused by the depression of the neck of the femur. The actual shortening, which is not often more than an inch, is usually increased by an upward tilting of the pelvis on the affected side, in compensation for the restriction of abduction, similar to the so-called practical shortening of hip disease. This practical shortening may be from one to three inches (Fig. 1575). Thus, as in genu varum and genu valgum, the direct effects of the deformity are the most characteristic symptoms, although in coxa vara there is usually greater discomfort than in the latter affections, because the interference with the function of the joint is more marked. The patient usually complains of sensations of weakness and discomfort after long standing or walking, and of stiffness on changing from a position of rest to one of activity. This discomfort, usually referred to the thigh and the neighborhood of the joint, may be increased to actual pain by overexertion or injury; in such instances there may be attendant muscular spasm which disappears with the subsidence of the acute symptoms.

Fig. 1575.—Unilateral Coxa Vara of an Extreme Degree. Showing great apparent shortening due to the adduction of the limb.

Bilateral Coxa Vara.—Bilateral coxa vara is far less common than the unilateral form. The limp is replaced by a waddle or swaying of the body from side to side, resembling the gait of knock-knees. The awkwardness and weakness are of course correspondingly increased, and in the extreme cases, in which the thighs are adducted, the limbs may be crossed so that walking is extremely difficult. The pelvis appears to be abnormally broad because of the elevated and prominent trochanters, and the lumbar lordosis is diminished (Fig. 1576) because of the loss of the normal inclination of the pelvis due to the forward displacement of the supporting femora. In the rare cases in which the femoral necks are distorted forward as well as downward, the lumbar

Fig. 1576.—Bilateral Coxa Vara, more Marked on the Right Side. Complete loss of abduction on both sides.

lordosis is increased and the appearances are somewhat similar to those of congenital dislocation of the hips (Fig. 1577). Bilateral coxa vara is usually an evidence of greater weakness than the unilateral form and in adolescence it is often accompanied by other static deformities.

The epiphyseal form of coxa vara is usually unilateral and differs from that described in that the articulation is directly involved and the disability is much greater (Fig. 1573,e). There is often almost complete fixation of the limb in part due to muscular spasm, and a corresponding increase of the pain and weakness. It is on this account almost always mistaken for hip disease. There is this important distinction, however, usually apparent on superficial examination. In epiphyseal coxa vara the limb is usually rotated outward and extended. In hip disease it is

always flexed. As has been stated, if the neck retains its normal angle, this form is always of traumatic origin.

Clinically, coxa vara is far more common in males than females and at least seventy-five per cent. of the cases are unilateral, indicating the importance of injury in the etiology.

Prognosis.—In the ordinary form of adolescent coxa vara the duration of the progressive stage of the deformity is about three years. Then the resistance of the compressed tissues may check its progress and

Fig. 1577.—Bilateral Coxa Vara, of the Anterior Form, Showing the Lordosis. An uncommon type that resembles congenital dislocation of the hips.

with stability and the further adaptation to the new conditions, function improves.

In the unilateral form the limp and shortening remain, and in the bilateral type a degree of disability and awkwardness, in proportion to the final restriction of the range of abduction. If the affection first appears in childhood, the progress of the deformity is slower, and it is often intermittent, increasing usually during adolescence. In this regard the affection resembles closely other distortions of similar origin (Fig. 1578).

Treatment.—Deformity of the neck of the femur cannot be remedied by braces. The part can be relieved, however, from strain by restricting the burden of occupation, and distortion may be checked by the use of a support, similar to that employed in the treatment of hip disease, by which the weight is borne upon the perineum.

Massage and exercises to improve the nutrition of the part, and manipulation with the aim of overcoming restriction of motion, may be of service also in the rachitic cases in early life. Therapeutic treatment is, of course, indicated in cases of this type.

As a rule, however, the only effective treatment is the correction of the deformity by operation, and this as a prophylactic measure may be indicated even in the younger class, in which the deformity is slight. For with the depression of the neck of the femur, the strain upon it becomes greater and thus there is a tendency to progressive deformity, which one may check by replacing the neck at its normal angle. This correction is most easily accomplished by the removal of a sufficient wedge of bone from the base of the trochanter. In this operation all resistance to abduction, other than that dependent upon the deformity of the bone, should be overcome by preliminary stretching, the base of the wedge, accurately determined by the $x$-ray picture, being of such size as will restore the normal angle. It is usually about three-quarters of an inch in width. Its base should be directly opposite the trochanter minor. The layer of cortical substance on the inner aspect of the bone should not be divided, but should serve to retain the two segments of the femur in proper relation to one another. When the wedge has been removed, the thigh should be gently abducted; the neck segment is first fixed by contact with the acetabulum and the shaft is then bent outward upon it until the opening is closed by apposition. In this attitude of normal abduction the limb

Fig. 1578.—Unilateral Coxa Vara of the Ordinary Form. A final result. The elevated and prominent trochanter, the shortening, and the outward rotation are shown.

is fixed by a plaster bandage until union is complete. As a rule, no apparatus is required in the after-treatment (Fig. 1579).

In certain instances, particularly those in which there is marked anteroposterior distortion of the neck, a simple linear osteotomy may be indicated. The shaft is then rotated inward to the proper degree before abducting it.

Fracture of the neck of the femur, or so-called *traumatic coxa vara*, is not uncommon in childhood and adolescence. In childhood the fracture is the direct

result of injury and is usually at the outer part of the neck. It is often incomplete, the neck being depressed by the opening of a wedge-shaped interval at the base, the resulting deformity being typical coxa vara.

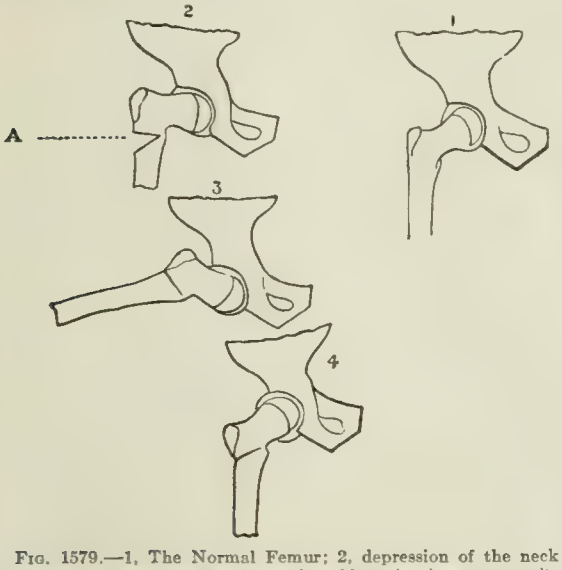


FIG. 1579.—1, The Normal Femur; 2, depression of the neck of the femur—coxa vara (at A a wedge of bone has been removed); 3, abduction of the limb first fixes the upper segment by contact with the rim of the acetabulum, then closes the opening in the bone; 4, replacement of the limb after union is completed elevates the neck to its former position.

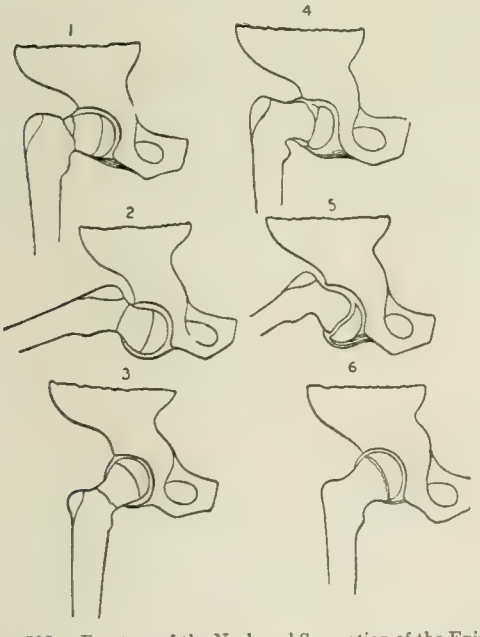


FIG. 1580.—Fracture of the Neck and Separation of the Epiphysis of the Femur. (Whitman's "Orthopedic Surgery.") 1, Fracture of the neck of the femur; 2, restoration of the normal angle by forcible abduction; 3, the limb in normal position; 4, 5, and 6 illustrate separation of the epiphysis of the head of the femur treated by the same method.

The immediate correction of the deformity is indicated by means of the abduction method. The patient being anesthetized, under manual traction and downward pressure on the trochanter the limb is slowly abducted to the normal limit as indicated by the range on the sound side; the outward rotation having been corrected, the limb is fixed by a long plaster spica until repair is complete. The mechanism of the correction is indicated in the diagrams. Abduction is checked by the contact of the depressed neck with the upper border of the acetabulum and further abduction restores the normal relation of the shaft to it.

If the fracture is complete the shortening is reduced first by manual traction and the limb is then placed in the attitude of complete abduction and fixed by a long plaster spica.

The advantages of this method are these. Abduction turns the outer fragment downward and inward toward the inner, the tension on the capsule aiding the alignment. Upward displacement is prevented by contact of the trochanter with the side of the pelvis and by the muscular relaxation assured by the attitude, while the plaster spica assures a firm anteroposterior support.

The epiphyseal fracture may be reduced by the same method in recent cases although more violent manipulation in flexion, inward rotation, and abduction is usually required to assure adjustment.

In the cases of longer standing in which the fragments are displaced and adherent, the joint should be opened by the anterior incision. A thin chisel is then inserted between the two fragments to separate and to pry them apart, adjustment being accomplished by traction combined with abduction and inward rotation of the limb aided by the leverage of the instrument.

Functional recovery is the rule in cases treated in this manner.

ROYAL WHITMAN.

**Crab-Orchard Springs.**—Lincoln County, Kentucky.

POST-OFFICE.—Crab Orchard. Boarding houses.

ACCESS.—Via Louisville and Nashville Railroad to Crab Orchard, 115 miles southeast of Louisville. The Springs are one-half mile from the station.

Crab Orchard, although in a valley surrounded by pine-clad mountains, is not swampy, but dry. It is noted for its variety of mineral waters, twelve distinct types being found within a radius of one mile.

These waters are chiefly used in the manufacture of the famous Crab-Orchard salts, which are used extensively in Kentucky and neighboring States as a cathartic. The following analyses were made by Dr. Robert Peter, State Geologist:

ONE UNITED STATES GALLON CONTAINS:

| Solids. | Epsom or Foley Spring, grains. | Sowder's Spring, grains. |
|---|---|---|
| Magnesium carbonate | 7.64 | 19.20 |
| Iron carbonate | Trace. | Trace. |
| Calcium carbonate | 53.18 | 29.51 |
| Sodium chloride | 17.72 | 58.32 |
| Potassium sulphate | 9.91 | 17.37 |
| Sodium sulphate | 59.07 | 23.20 |
| Magnesium sulphate | 205.28 | 174.31 |
| Calcium sulphate | 10.79 | 91.32 |
| Bromine | ..... | Trace. |
| Silica | 3.26 | 1.22 |
| Loss and moisture | 34.58 | [illegible] |
| Total | 401.43 | 414.45 |

Carbonic acid not estimated

CRAB-ORCHARD SALTS.

| 100 PARTS CONTAIN: | Parts. |
|---|---|
| Magnesium sulphate | 63.19 |
| Sodium sulphate | 4.20 |
| Potassium sulphate | 1.80 |
| Calcium sulphate | 2.54 |
| Sodium chloride | 4.77 |
| Lime, magnesia, iron, and silica (carbonates) | .89 |
| Bromine | Trace. |
| Water of crystallization and loss | 22.61 |
| Total | 100.00 |

Among the springs are the Salt Sulphur, the White Sulphur, and the Black Sulphur. The waters have proved useful in disorders of the stomach, bowels, liver, and kidneys.

Other springs at Crab Orchard are the "Field" and the "Grove" springs, which are but feebly impregnated with mineral ingredients.

EMMA E. WALKER.

**Cramp Bark.**—See *Viburnum Opulus*.

**Cramps.**—Cramp is a term applied to denote a painful tonic muscular contraction of some moments' or minutes' duration. As several of these painful contractions generally occur successively, the term "cramps" is used to designate the attack. Cramps belong to the local spasmodic disorders; cramp is, in fact, technically a local tonic spasm, to which is added the element of pain. It is true that in tetanus there is a general cramp of almost the entire voluntary muscular system, and that in cholera cramps are widely diffused; nevertheless medical usage assigns the term cramps to the local spasmodic disorders.

Properly speaking, cramps may affect both the voluntary and the involuntary muscles. Writers sometimes speak of cramps of the heart, of the stomach, intestines, bladder, and uterus; but, as a rule, these cramps of the involuntary muscles are given the term colic. Cramps of the voluntary muscles are strictly analogous, therefore, to colic of the involuntary muscles.

The further relations of cramps to the other hyperkineses are shown in the article on *Convulsions*. In this description of cramps we shall limit the application of the term, as is usually done, to the voluntary muscles.

CLINICAL HISTORY.—The voluntary muscles oftenest affected by cramps are those of the extremities, and especially those of the lower extremities. The muscles most susceptible are the gastrocnemii and plantar muscles. The psoas muscle, and flexors of the thigh upon the abdomen, are also at times affected. In the upper extremities it is the muscles of the fingers that are most often attacked. In the special neurosis of which writer's cramp is a type, the muscles of the whole arm may also be involved. Of the trunk muscles, those forming the soft wall of the abdomen are not infrequently affected with slight cramps. After a violent sneeze, for example, part of the rectus may become knotted up in a cramp. In cholera the abdominal muscles are all involved. A sudden "stitch in the side," is due to a cramp of some of the intercostal muscles. A crampy condition of the sternocleidomastoid and of part of the trapezius is observed in the clonic forms of wry-neck. The muscles of the face, of the eye, and of mastication, are not subject to cramps, except in very rare cases and as part of some general disorder.

When the term cramp is used, without further special designation, it refers to painful spasms in the extremities, especially the lower extremities. Attacks of such spasms come on generally at night, or after some violent exertion, such especially as swimming, when the circulation in the extremities is disturbed by the cold water. The pain and contraction come on suddenly, as a rule, though sometimes slight premonitory twinges are felt. The muscle is contracted, and feels hard and knotty, the limb is drawn up, and attempts to straighten it or to relax the muscle give great pain. The patient often feels a sensation of nausea, depression, and even of faintness. Pressure on the affected part gives relief, and forcible rubbing or sudden extension of the muscle will often relax the spasm. No especial change in the electrical relations has been observed. The attack lasts only a few seconds or minutes, as a rule, but it may continue for hours. After one attack has gone, a second and third may succeed. A patient may have to get up half a dozen times a night on account of his seizures.

When the spasms have disappeared, the muscle is left sore and tender to the touch, owing to stretching of the muscle and the irritation and injury to the sensory nerves.

ETIOLOGY.—Cramps in the extremities occur as the result of organic disease of the brain and spinal cord, of local vascular disease, and as the result of certain functional morbid conditions. Pressure on, or irritation of, nerve trunks sometimes causes cramps. The cramps of organic disease I do not purpose to consider here. The causes of the functional cramps are various. In some persons there is an inherited or connate tendency to this trouble. Cramps occur more frequently in the aged and in growing children than at the middle period of life. Gouty and rheumatic conditions, and anemia, predispose persons to them. In disordered states of the stomach and bowels nocturnal attacks of cramp occur. Cramps in the lower extremities are often an annoying disturbance of pregnancy. In the early months the gastrocnemii and plantar muscles are most affected; later the thighs are drawn up by painful contractions of the psoas and other flexors. These cramps of pregnancy are probably at first reflex in character; later they are due to the pressure of the gravid womb on the nerves which supply the lower limbs.

Cramps of a distressing character occur in Asiatic cholera and cholera nostras. They are also observed in persons of intemperate habits. Arterial sclerosis involving the vascular supply of the legs is a cause of leg cramps of elderly people. In conditions of arterial sclerosis, a cramp occurs usually while the patient is walking (intermittent limping).

Probably the most frequent of all the exciting causes of ordinary forms of cramps in the extremities is violent exercise, such as swimming, dancing, walking, running, and jumping.

PATHOLOGY.—In the ordinary type of cramps the muscle itself is at fault. Through deficient nutrition or overuse its fibers are irritated, an involuntary contraction results which is painful because it is so abnormally powerful that the sensory nerve fibers are pressed upon. Tonic spasms become painful and crampy in character, therefore, simply because of a quantitative excess in muscular contraction. No one can voluntarily knot up his calf muscles as is done in a cramp. The myopathic character of the contraction is shown by the fact that, by the pressure of bands and tourniquets, which alters the blood supply to the muscles, the cramps can often be relieved.

There are, however, certain forms of cramps, like wry-neck, or writer's cramp, that are of purely central nervous origin. Here the cramp is due to overstimulation of the muscle.

TREATMENT.—The treatment of the ordinary type of leg cramps must be addressed first to the general condition. Rheumatic, gouty, and neurasthenic tendencies must be corrected, dyspepsia and constipation relieved. If the attacks are unusually severe and obstinate, the question of diabetes or of some organic disease must be investigated. A number of devices have been recommended for preventing the attacks.

Among these, one which I have found successful is tying a tape about each thigh just above the knee. This is done just before retiring. Raising the head of the bed by placing one or two bricks under the posts is a measure which I have not found to do any good. A dose of bromide with alkalies at night, or a mixture containing gr. v. each of lupulin and camphor, may be given. In severe cases, especially in pregnancy, codeine or opium may be added to these. Massage and faradization of the limbs will sometimes ward off attacks, and so will small doses of strychnine continuously administered.

When the attack comes on, the affected muscles must be vigorously rubbed and kneaded. If the patient jumps up at once and puts the muscles on the stretch, he can often break up the cramp. A little rubbing and exercise will then quiet the muscle. In the cramps of later life due to arterial sclerosis this condition must be treated. CHARLES L. DANA.

**Cranial Nerves.**—From the standpoint of the peripheral nervous system the organs of the body may be conveniently divided into three groups: (1) the organs of the trunk region, whose spinal nerves are evidently arranged in a segmental way; (2) a series of respiratory, gustatory, and other visceral organs, innervated from the medulla oblongata and in lower vertebrates intimately associated with the gills (branchial region); (3) the organs of the head, devoted largely to the higher senses and their central connections within the brain and to the higher cerebral association centers. The limits of these regions and their distinguishing characteristics are more evident in lower vertebrates than in higher.

The branchial region of some lower fishes is very extensive and it has a characteristic segmentation (branchiomerism) which is of quite different character from that of the trunk region, though the two segmental patterns may overlap. In the trunk the organs are partly of somatic type, being concerned mainly with locomotion and other similar reactions of the body musculature to external stimuli, and partly visceral systems whose nerve supply is much smaller and which receive their nerves in part from the branchial region. But the branchial region is dominated by the gills, which are visceral structures, while the somatic systems are here greatly reduced. In mammals the gills have disappeared, but the associated part of the brain, the medulla oblongata, preserves its character as a center devoted chiefly to respiratory and other visceral functions.

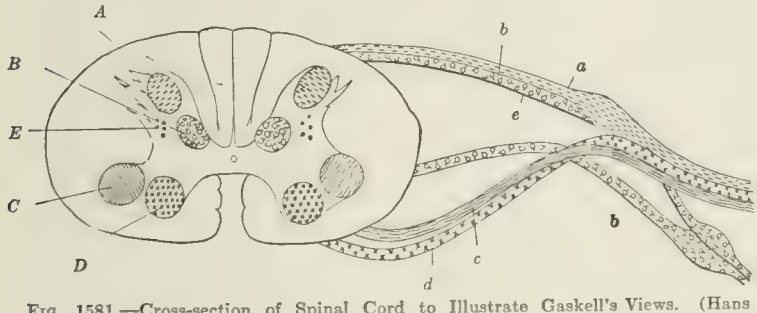


FIG. 1581.—Cross-section of Spinal Cord to Illustrate Gaskell's Views. (Hans Gadow.) *A*, Cells of dorsal horn; *B*, cells of Clarke's column; C, cells of lateral horn; *D*, cells of ventral horn; *E*, solitary cells at base of dorsal horn; *a*, somatic afferent fibers; *b*, splanchnic ganglionated efferent fibers; *c*, splanchnic non-ganglionated efferent fibers for visceral and enteric muscles; *d*, somatic efferent fibers; *e*, splanchnic afferent fibers.

Thus, the V., VII., IX., X., and XI. cerebral nerves are of branchiomeric type, with visceral functions predominating. The I., II., III., IV., VI., and VIII. nerves belong to the organs of special sense and their accessories, while the XII. cerebral nerve is a modified spinal nerve. Comparative anatomy and embryology show that most of these nerves (and perhaps all) are the descendants of more typical segmental nerves, but in all existing vertebrate types the original segmental pattern has been more or less highly modified and obscured. In the human body this modification has been carried much farther than in the lower vertebrates, and accordingly much valuable information regarding the significance and relationship of the cerebral nerves has been derived from the study of fishes and other more primitive vertebrate animals.

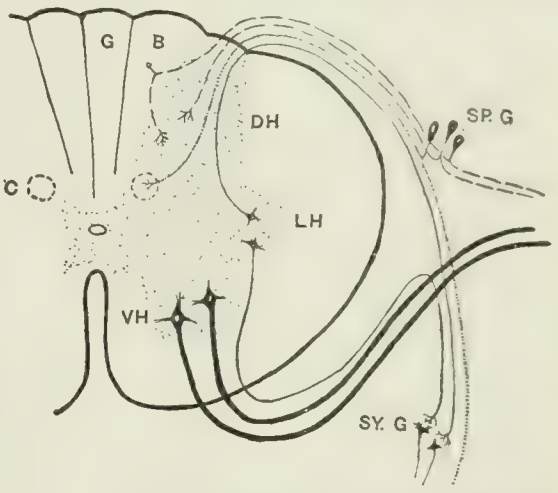


FIG. 1582.—Diagram Illustrating the Composition of the Typical Spinal Nerve. The somatic sensory fibers are represented by broken lines, the visceral sensory by dotted lines, the somatic motor by heavy continuous lines and the visceral efferent by lighter continuous lines. Visceral efferent fibers are found in the dorsal roots of some lower vertebrates; their presence in mammals is controverted. Fibers of the visceral efferent system arise chiefly from an intermedio-lateral column of cells which lie in or near the outer border of the lateral cornu. The central terminus of the visceral sensory fibers is uncertain, probably in the intermediate zone in the vicinity of the nucleus dorsalis of Clarke. *B*, Fasciculus cuneatus (of Burdach); *C*, nucleus dorsalis (of Clarke); *DH*, dorsal horn; *G*, fasciculus gracilis (of Goll); *LH*, lateral horn containing the intermedio-lateral column of cells; *SP.G*, spinal ganglion; *SY.G*, sympathetic ganglion; *VH*, ventral horn.

*The Doctrine of Nerve Components.*—The knowledge of the composition of the cranial nerves was long retarded by persistent attempts to analyze them in accordance with the analogy of a supposed simple spinal pattern. Sir Charles Bell in the early part of the nineteenth century made plain the difference between the sensory and motor roots of the cranial and spinal nerves. But the common statement of Bell's law, that the dorsal spinal roots are sensory and the ventral roots are motor, leaves out of consideration important parts of his scheme and ascribes to the spinal nerves a really artificial simplicity. The attempt to classify the still more complex cranial nerves in accordance with this simplified segmental scheme, thus treating all sensory roots as metamerically equivalent structures and all likewise as directly homologous with spinal motor roots, has resulted only in confusion.

Gaskell in 1886 and 1889 amplified Bell's analysis of the spinal nerves and elaborated a four-root theory which has been the point of departure for the best recent studies upon the composition of the peripheral nerves. The details of Gaskell's scheme have been greatly modified, but the fundamental distinction

which he clearly drew between somatic and visceral systems of nerve components has been more and more evidently justified as time passed on. Fig. 1581 illustrates the chief features of Gaskell's analysis of the spinal nerves, each segmental nerve containing somatic afferent and efferent fibers and also visceral afferent and efferent fibers, all of the afferent fibers and some of the efferent visceral fibers being ganglionated.

The present conception of the composition of the spinal nerves is illustrated by Fig. 1582. Here it is seen that the typical spinal nerve contains two great groups of fibers, the somatic and the visceral, each with afferent and efferent subdivisions. The somatic group is concerned with the adjustments of the body to the outside world (exteroceptive systems of Sherrington); the visceral group (interoceptive) is concerned with the internal mechanisms of circulation, digestion, etc., and its connections are made through the sympathetic nervous system (see further under *Brain, Anatomy*).

The somatic efferent fibers are non-ganglionated and pass directly from their cell bodies in the ventral horn of the spinal cord through the ventral roots to end upon the fibers of skeletal muscles. The somatic afferent fibers are formed by the bifurcation of the single processes of the cells of the spinal ganglia which thus give rise to centrally and peripherally directed processes. The central processes form the larger part of the fibers of the dorsal spinal roots and terminate, after a longer or shorter course within the spinal cord, about cells of the dorsal horn or nuclei of the dorsal funiculi. The peripheral processes end in receptive organs in or immediately under the skin (exteroceptors) or else in deep sense organs among the muscles, tendons, joints, etc. The latter are termed by Sherrington proprioceptors and serve for the internal regulation of the somatic organs of response and not, like the interoceptors, for visceral reactions. The somatic motor and sensory roots of the cranial nerves are organized in essentially the same way as those of the spinal nerves just described.

The visceral fibers of the spinal nerves are less numerous than the somatic fibers and they are chiefly efferent in function. These visceral efferent fibers arise from the intermediate zone of the spinal cord between the dorsal and ventral horns and especially from an intermedio-lateral column of cells lying within and just external to the lateral horn (Bruce). They probably do not arise from the cells of Clarke's column, as suggested by Gaskell. They do not reach their terminal organs (smooth muscles, glands, etc.) directly, but always end in some sympathetic ganglion, with whose cells they effect functional connection. The impulse is then carried on to the peripheral organ by axones of these sympathetic cells. The neurone of the first order, whose cell body lies within the central nervous system, is termed the preganglionic neurone; the neurone of the second order is the postganglionic neurone (Langley).

The visceral sensory fibers of the spinal nerves are relatively very few in number. Some such fibers arise from cells of the spinal ganglia, whose peripheral processes distribute through the sympathetic nervous system to mucous surfaces, etc., and whose central processes enter the spinal cord through the dorsal roots to terminate probably in the intermediate zone of gray matter at the base of the dorsal horn. It is probable that some cells of the sympathetic ganglia also send sensory processes centripetally through the rami communicantes to enter the spinal ganglia and thus after a synapse in the ganglion to discharge into the dorsal roots of the spinal nerves. But our knowledge of these fibers is still very incomplete.

The cranial nerves exhibit a much more complex and diversified pattern than do the spinals. The primary segmentation is obscure and there is still some difference of opinion as to the segmental relations of the twelve pairs (of Sömmering) as now commonly enumerated. These twelve pairs are convenient anatomical units, but for physiological and clinical purposes a more useful unit is the *functional system*. Each system may be defined as the sum of all the nerve fibers in the body, which possess certain physiological and morphological characters in common, so that they may react in a common mode. Morphologically, each system is defined by the terminal relations of its fibers—by the organs to which they are related peripherally and by the centers in which the fibers arise or terminate. The fibers of a single system may appear in a large number of nerves, repeated more or less uniformly in a metameric way (as in the cutaneous nerves of the spinal cord), or they may all be concentrated into a single nerve (as in the olfactory nerve). On the other hand, a single nerve may contain several components; *i.e.* its fibers may belong to several of these systems. It becomes necessary, therefore, to analyze the root complex of each pair of cranial nerves into its components and to trace not only the central connections of these components within the brain, but also their peripheral courses as well. In other words, the description of any given ramus is not complete when we have given its point of origin from the nerve trunk or ganglion, the details of its devious courses and the exact points where the several ramuli terminate. In addition to this it is necessary to learn what functional systems are represented in the ramus and the precise central and peripheral relations of each system.

The difficulty in determining this latter point is the chief obstacle in the way of researches on the nerve components; for, while the central connections of any nerve can be determined by the microscopical method and by various experimental procedures, the peripheral courses are usually studied by gross methods which reveal nothing of the precise relations of the several components and hence do not permit a knowledge of each system as a whole. To trace the components of the more complex cranial nerves continuously from their central nuclei of origin or termination by means of serial sections to their ultimate peripheral connections has never been attempted in the human body. In some lower vertebrates, however, this has been accomplished with a fair measure of success. The pioneer work in this field was done by Dr. Oliver S. Strong in 1895 on the frog tadpole, and this has been followed by many similar studies. All of the types thus far examined in this way exhibit certain broad general resemblances and permit the establishment of a schematic type of cranial nerve components which is presumably applicable to the vertebrates as a whole. From anatomical, physiological, and pathological data already in hand it is possible to compare the human nerves with this scheme and to infer the composition of most of the peripheral rami with more or less of accuracy.

In the branchial region of the lowest fishes the gills are very numerous (as many as seventeen pairs in some cyclostomes) and each gill is supplied by a branchiomeric nerve. The segmentation of these gills does not coincide with that of the myomeres of the same region and it is a controverted point whether this diversity is primary or a secondary modification. But it is clear that in primitive vertebrates the entire branchial region contained greatly enlarged visceral structures, the gills, and also somewhat reduced somatic structures, the myomeres, or body musculature, and the sensory organs of cutaneous and muscular sensibility. The somatic motor roots in the branchial region of fishes are usually enumerated as spinal nerves. They all disappear in mammals, except one or more of the ventral roots which are represented in the hypoglossus nerve.

In primitive vertebrates (cyclostomes) the typical nerve of this region contains sensory and motor somatic fibers arranged in series of dorsal and ventral roots as

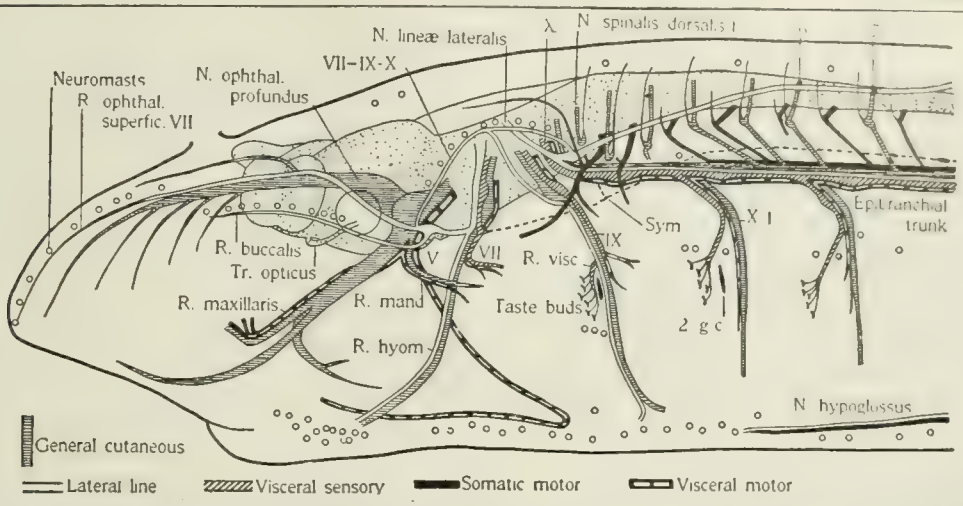


FIG. 1583.—A Reconstruction of the Cranial Nerves of a Cyclostome Fish, *Petromyzon dorsatus*, seen from the Left Side, to Show the Arrangement and Distribution of the Several Systems of Nerve Components. The general or unspecialized somatic sensory system (general cutaneous) is shaded with horizontal lines; the special somatic sensory system (lateral line) is drawn in outline without shading, the VIII nerve, which also belongs to this system, being omitted. Only three of the gill clefts are indicated in the drawing. 2 *g.c.* marks the second gill cleft; its branchiomeric nerve is the first division of the vagus (*XI.*). The sympathetic nervous system is indicated by a broken line (*Sym.*). (After Johnston.)

in the spinal nerves, and in addition an intermediate or lateral series of visceral sensory and motor roots for the branchial apparatus. During the course of vertebrate evolution the branchial region has been greatly shortened (chiefly by suppression of the more caudal branchiomeres), resulting in the loss of the more caudal lateral roots. The remaining branchiomeric nerves tend to be combined into a common vago-accessorius trunk. Meanwhile the myomeres and the corresponding somatic nerve roots were reduced in number from before backward. Fig. 1583 illustrates an early phase of this metamorphosis of the branchial region, as seen in cyclostome fishes. In some higher fishes a section through the region of the vagus nerve (Fig. 1584) shows that here the somatic motor component has entirely disappeared (though present at this level in some other teleosts), while the somatic sensory system is represented by a small cutaneous root and ganglion. The latter becomes in man the ramus auricularis vagi, while the somatic motor system is here represented by the hypoglossus nerve. In mammalian embryos, where gill clefts and gill arches are still preserved, the branchiomeric nerves are related in all fundamental respects as in fishes, and the data of comparative anatomy and comparative embryology are essential to a proper understanding of the adult relations.

A comparison of the composition of the nerves of the trunk and branchial regions reveals in both cases the fundamental distinction between the somatic and visceral divisions. In the trunk region each of the four primary components of a spinal nerve is further subdivided into functional systems (for various forms of cutaneous and deep sensibility, various functionally related groups of muscles, etc.), but all of these systems are relatively unspecialized. In the nerves of the branchial and cerebral regions, on the other hand, we have, in addition to unspecialized components like those of the spinal nerves, also highly specialized derivatives, each with a particular function and a more or less elaborately differentiated peripheral and central terminal apparatus. Thus the four primary divisions of the spinal nerves are represented by eight divisions in the cranial nerves, arranged in the human body as follows:

1. General somatic motor, supplying myomeres of the general bodily or skeletal musculature. This system is present in the branchial region of fishes, but is lost in mammals, except perhaps a part of the fibers of the XI. nerve for the trapezius muscle.

2. Special somatic motor, supplying specialized striated muscles derived from the myotomes; viz., the eye muscles and a part of the tongue muscles; III., IV., VI., and XII. nerves.

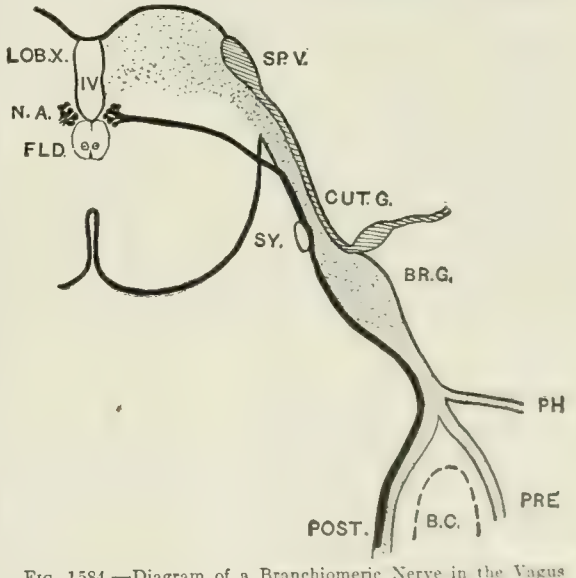


FIG. 1584.—Diagram of a Branchiomeric Nerve in the Vagus Region of a Teleostean Fish (*Menidia*). The visceral sensory component is stippled; the visceral efferent is drawn in black (these two constituting the branchiomeric nerve proper). The somatic sensory system is cross hatched. The somatic motor system is here absent, though in some other fishes fibers of this system arise at this level from cells lying ventrally of the nucleus ambiguus and form an independent ventral root. *B.C*, Branchial cleft; *BR.G*, branchial ganglion; *CUT.G*, general cutaneous or somatic sensory ganglion; *FLD*, fasciculus longitudinalis medialis; *IV*, fourth ventricle; *N.A*, nucleus ambiguus; *LOB.X*, lobus vagi, the terminal nucleus of the visceral sensory fibers; *PH*, ramus pharyngeus; *POST*, posttrematic ramus; *PRE*, pretrematic ramus; *SP.V*., spinal V. tract, associated with the terminal nucleus of the somatic sensory fibers; *SY*, sympathetic ganglion.

3. General visceral motor, preganglionic nerve

fibers distributing through the sympathetic nervous system for unstriped or cardiac visceral muscles, glands, etc.; represented in the III., VII., IX., X., and XI. nerves.

4. Special visceral motor, supplying highly differentiated striated muscles which are connected with the gills or their derivatives and which are derived embryologically, not from the myotomes, but from the unsegmented ventral mesoderm. These nerve fibers in the adult resemble those of the somatic motor system save for their origin from a different series of motor nuclei in the brain. They do not enter the sympathetic nervous system and are not related to postganglionic neurones. This group is represented in the V., VII., IX., X., and XI. nerves.

5. General somatic sensory, supplying general sensibility to the skin and deep sensibility to the muscles, tendons, etc. In the lowest fishes this group is represented in all segments of the branchial region, but in man its cutaneous fibers are limited to the V., IX., and X. nerves. Fibers for muscle sense are found in the III., IV., V., and VI. nerves, and probably others.

6. Special somatic sensory, specialized nerves for the innervation of highly differentiated sense organs derived phylogenetically from the cutaneous organs of general sensation. In fishes the very extensive nerves of the lateral line organs belong here. In man this group is represented only by the VIII. nerve and (probably) by the visual organ related with the so-called II. nerve.

7. General visceral sensory, for the innervation of visceral mucous surfaces without highly differentiated sense organs. The relations of these fibers are not clearly understood, as they are mingled with the much more numerous fibers of the next group. They distribute chiefly or wholly through the sympathetic nervous system and are probably represented in the VII., IX., and X. nerves.

8. Special visceral sensory, for the innervation of specialized end-organs serving the sense of taste and probably also the sense of smell. The gustatory fibers are clearly related to the unspecialized visceral sensory system and are represented in the VII., IX., and X. nerves. The olfactory nerve (I. nerve) is probably a more highly differentiated member of the same group.

In the accompanying table the components of the twelve pairs of cerebral nerves as commonly enumerated are analyzed in accordance with the preceding scheme.

Table of Cranial Nerve Components.

| Nerve. | Components. | Chief functions. | Cells of origin. | Nerve roots. | Primary nuclei and secondary connections. | Chief rami. |
|---|---|---|---|---|---|---|
| I | Special visc. sens | Smell | In nasal muc. membrane | Fila olfactoria | Olf. bulb; lat. olf. area; med. olf. area; uncus; hippocampus | |
| II | Special som. sens. | Vision | In retina | . . . . . | Retina; optic nerve and tract to thalamus and midbrain | Not a true nerve. |
| III | Special som. efferent | Movement of eyeball | III. nucleus | III. root | To III. nuc. from med. obl. by fasc. long. med.; from tectum opticum and cerebral cortex | Branches to mm. rectus sup., rectus inf., rectus int., obliquus inf., levator palpebræ sup. |
| | General visc. efferent | Intrinsic muscles of eyeball | Nucleus of Edinger-Westphal | III. root | Do.? | Preganglionic fibers to g. ciliare; postganglionic fibers in ciliary nerves |
| | General som. sens. | Muscle sense of eye muscles | ? | III. root | ? | Fibers mingled with motor fibers to four eye muscles |
| IV | Special som. efferent | Movement of eyeball | IV. nucleus | IV. root | To IV. nuc. same as III. nerve | Nerve of m. obliquus superior |
| | General som. sens. | Muscle sense | ? | IV. root | ? | Fibers mingled with motor fibers to m. obliquus superior |
| V | Special visc. efferent | Movement of jaws | Motor V. nucleus | Portio minor V. | To mot. V. nuc. from sens. V. nuc., mesenc. V. nuc., cerebellum and cerebral cortex | By n. mandibularis to temporal, masseter, ext. and int. pterygoid, tensor palati, tensor tympani, ant. belly of digastric and mylohyoid muscles |
| | General som. sens. | A. gen sens skin of head, nose, teeth, mouth, meninges | G. semilunare (Gasseri) | Portio major V. | From sens. V. nuc. and spinal V. nuc. to mot. nuclei of obl. and cord, to cerebellum, nuc. lat. thalami and cortex | N. ophthalmicus, n. maxillaris, n. mandibularis |
| | | B. muscular sens. of jaw muscles | Nuc. mesencephalicus V. | Portio major V. | From root fibers and nuc. mesenc. to mot V. nuc. and other motor centers | Fibers distribute with muscular branches of V. |
| VI | Special som. efferent | Movement of eyeball | VI. nucleus | VI. root | To VI. nuc. from sup. olive; also same connections as III. nerve | Nerve of m. rectus lateralis |
| | General som. sens. | Muscle sense | ? | VI. root | ? | Fibers mingled with motor fibers to m. rectus lateralis |
| VII | General visc. efferent | Secretion of saliva | Nuc. salivatorius superior | Portio intermedia | To nuc. saliv. from nuc. of fasc. sol. and other sens. centers; cortex | Preganglionic fibers in chorda tympani; postgang. fibers from submax. gang. to submax. and sublingual glands |
| | Special visc. efferent | Hyoid and facial musculature | Motor VII. nucleus | Portio dura | To mot. VII. nuc. from sens. nuclei of oblongata and cortex | Stapedius, post. belly of digastric, stylohyoid, auricular and scalp muscles and superficial facial musculature |
| | General visc. sens. | Deep visc. sensibility | G. geniculatum | Portio intermedia | From nuc. of fasc. sol. to formatio reticularis | Probably in great superf. petrosal and chorda tympani and tympanic plexus |
| | Special visc. sens. | Taste on ant. part of tongue | G. geniculatum | Portio intermedia | From nuc. of fasc. sol. to mot. nuclei of oblongata and cortex | Chorda tympani |
| VIII | Special som. sens. | A. equilibration and static sense | G. vestibulare | Radix vestibularis | From vestibular nuclei and cerebellum to eye-muscle nerves, motor centers of obl. and cord | Nervus vestibuli |
| | | B. hearing | G. spirale | Radix cochlearis | From dors. and vent. coch. nuc. and sup. olive to collic. sup., corp. genic. med., cortex | Nervus cochleæ |

TABLE OF CRANIAL NERVE COMPONENTS—*Continued*

| Nerve. | Components. | Chief functions. | Cells of origin. | Nerve roots. | Primary nuclei and secondary connections. | Chief rami. |
|---|---|---|---|---|---|---|
| IX | General visc. efferent | Secretion of saliva | Nuc. salivatorius inferior | Motor IX. root? | To nuc. saliv. from nuc. of fasc. sol. and other sens. centers; cortex | Preganglionic fibers [illegible] and small superf. petrosal nerves; postgang. from otic ganglion to parotid gland |
| | Special visc. efferent | Movement of pharynx | Nuc. ambiguus | Motor IX. root | To nuc. ambiguus from nuc. of fasc. sol. and other sens. centers. | Ramus stylopharyngeus IX. |
| | General visc. sens. | Sensation of pharynx, etc. | G. petrosum IX. | Sens. IX. root | From nuc. of fasc. sol. to visc. motor centers | Pharyngeal and tympanic branches of IX. and various sympathetic connections? |
| | Special visc. sens. | Taste on post. part. of tongue | G. petrosum IX. | Sens. IX. root | From nuc. of fasc. sol. to visc. mot. centers and cortex | Ramus lingualis IX. |
| | General som. sens. | Tactile sense on post. part of tongue | G. superius IX. | Sens. IX. root | From nuc. of spinal V. tract to mot. centers | Ramus lingualis IX. |
| X | General visc. efferent | Unstriped muscles and glands of gut and other viscera | Dorsal mot. nuc. of X. | Motor X. | To mot. X. nuc. from nuc. of fasc. sol. and other sensory centers | Rami for pharynx, esophagus, stomach, heart, lungs, etc., via symp. system [illegible] fibers) |
| | Special visc. efferent | Striated muscles of pharynx | Nuc. ambiguus | Motor X. | Do.; also from cerebral cortex | Superior and inferior laryngeal and pharyngeal nerves |
| | General visc. sens. | Visc. sens. of pharynx, thorax, and abdomen | G. nodosum | Sensory X. | From nuc. of fasc. sol. and dors. sens. nuc. to visc. mot. centers (and cortex?) | Rami from pharynx, esophagus, stomach, heart, lungs, etc., and various symp. connections |
| | Special visc. sens. | Taste in region of epiglottis? | G. nodosum? | Sensory X. ? | Do.? | Probably in internal laryngeal nerve |
| | General som. sens. | Cutaneous sens. behind ear | G. jugulare X. | Sensory X. | From nuc. of spinal V. tract to motor centers | Ramus auricularis vagi |
| XI | General visc. efferent | Same as in X. nerve | Dorsal mot. nuc. of X. | In cerebral roots of XI. | Same as in X. nerve | Preganglionic fibers distributed with the vagus |
| | Special visc. efferent | A. striated muscles of pharynx | Nuc. ambiguus | In cerebral roots of XI. | To nuc. ambiguus from visc. sens. centers | To striated muscles of the pharynx accompanying vagus branches |
| | | B. movement of shoulder | Lateral horn of spinal cord | In spinal roots of XI. | To lat. horn from cord, oblongata, and cortex | Rami to trapezius and sternomastoid muscles |
| XII | Special som. efferent | Movement of tongue | XII. nucleus | XII. roots | To XII. nuc. from nuc. of fasc. sol. and other sens. centers and cortex | Hypoglossus nerve |

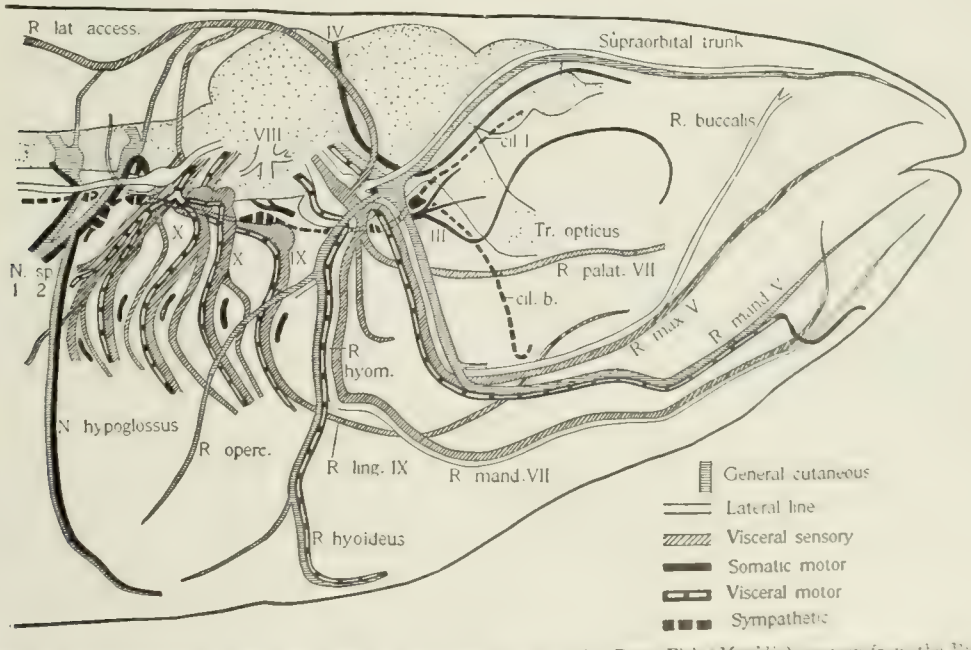


FIG. 1585.—A Reconstruction of the Chief Rami of the Cranial Nerves of a Bony Fish (*Mesidia*) as seen from the [illegible] Side, to Show the Arrangement of the Nerve Components. Compare Fig. 1583, of a lower type of fish. (After Herrick, from *Manual of Nervous System.*)

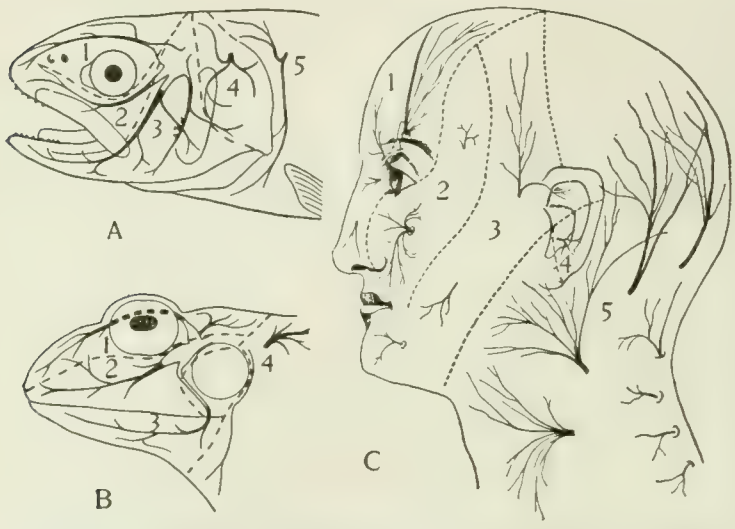


FIG. 1586.—Three Sketches to Illustrate the Distribution of the Cutaneous Nerves of the Head in a Fish, an Amphibian and Man. *A*, A teleostean fish; *B*, a frog; *C*, man, the figure being slightly modified from Cunningham's Anatomy by the addition of the ramus auricularis vagi. In all of the figures, area 1 is supplied by the ophthalmic division of the trigeminus; area 2 is supplied by the maxillary division; area 3 is supplied by the mandibular division; area 4 is supplied by the vagus; and area 5 is supplied by the spinal nerves. (After Johnston, Spengel's Ergebnisse und Fortschritte der Zoologie.)

An examination of the composition of the cerebral nerves in the different members of the vertebrate phylum shows that, as we pass from the lower to the higher members of the series, each functional system tends to become integrated from a diffuse segmental arrangement to a more compact form. For instance, the general cutaneous system in lower fishes (Fig. 1583) is represented in most of the cerebral nerves behind the IV. pair, and there is embryological evidence that in still more primitive forms this system was present farther forward as independent profundus and thalamic nerves. But in higher fishes (Fig. 1585) practically all of the cutaneous surface of the head is supplied from the V. pair and the vestige of this system which is still found in the X. pair terminates centrally in connection with the spinal V. tract; and the same is true in the human body. Parallel with the reduction of somatic nerves in the branchial region, an increasingly large part of the skin of the head is innervated, in higher vertebrates, by branches of true spinal nerves lying farther back, as illustrated in Fig. 1586.

Similarly, the gustatory system, which is widely distributed in fishes in the buccal and branchial region and sometimes even in the outer skin, in man is much more circumscribed. And again, the VIII. nerve of man is the sole survivor of an extensive system of cutaneous sense organs found in fishes (the acustico-lateralis system), whose nerve supply passes out in connection with several of the other cerebral nerves. There is some evidence that even the eyes were originally represented in several segments of the head (Locy).

The convergence of the fibers belonging to each functional system, no matter by what nerve roots they may enter the brain, so that all fibers of the same system terminate in a distinct cerebral center, is seen in Fig. 1587 which illustrates the composition of the nerve roots of the same animal as Fig. 1585, with a part of the central course of the several nerves sketched in. In the lower fishes the centers reached by these several systems of nerve fibers are clearly marked by eminences on the surface of the medulla oblongata or in the walls of the fourth ventricle (Fig. 1588). In the human medulla oblongata the same regions may be identified, though they are not so clearly seen from the surface (cf. *Brain, Anatomy*).

*Development.*—A brief account of some of the processes involved in the early embryology of the peripheral nerves will be found in the articles, *Brain, Anatomy, and Spinal Cord.* The entire dorsal ectoderm of the embryo may be regarded as potentially nervous. Along the middorsal line this ectoderm is invaginated to form the central nervous system. Other cells are proliferated on each side of the body along the seam or line of separation between the neural

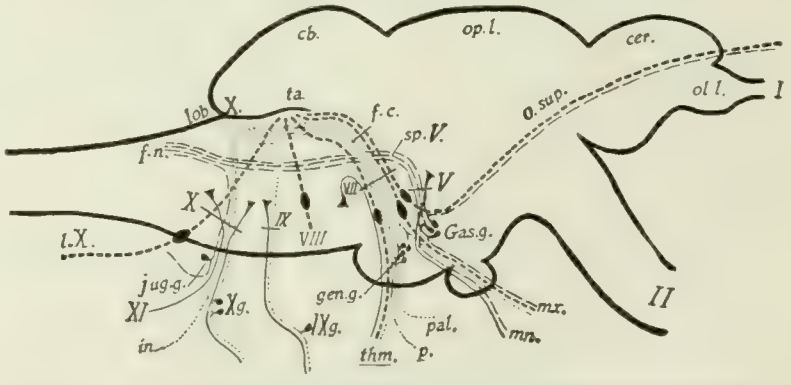


FIG. 1587.—The Cranial Nerves of *Menidia* as seen from the Right Side, Illustrating the Central Convergence of the Sensory Components of the Several Nerves into Functional Systems. The eye-muscle nerves have been omitted, the superficial origins of the others being indicated by the Roman numerals at the transverse lines drawn across their roots. The visceral motor roots are drawn as continuous lines, the general somatic sensory roots as broken lines, the acusticolateral (special somatic sensory) system as heavier broken lines, and the visceral sensory system as dotted lines. The positions of the auditory and of the four lateral line ganglia are indicated, though no special designations are given them. This scheme can be applied with but slight modification to all of the fishes. The student of comparative anatomy will notice that some rami peculiar to the teleosts have been omitted, *e.g.* the r. lateralis accessorius. Compare the detailed plot from which this diagram is drawn off, *Journal of Comp. Neurology*, vol. ix., plate xvi. The scheme can be adapted to higher vertebrates (including man) by the suppression of the lateral line roots of the facialis and vagus, leaving the VIII. nerve as the only representative of the acusticolateral system.

*cb*, Cerebellum; *cer*, cerebrum; *f.c*, fasciculus communis (=fasc. solitarius); *f.n*, terminal nucleus of spinal V. tract; *Gas. g*, Gasserian ganglion; *gen.g*, geniculate ganglion; *in*, ramus intestinalis vagi; *IX. g*, glossopharyngeal ganglion; *jug.g*, jugular (gen. cutaneous) ganglion of the vagus; *lob.X*, lobus vagi (sensory vagus nucleus); *l.X*, ramus lateralis vagi; *mn*, ramus mandibularis V; *mx*, ramus maxillaris V.; *ol.l*, olfactory lobe; *op.l*, optic lobe; *o.sup*, superficial ophthalmic branches of the VII. and V. nerves (the latter=frontal nerve of man); *p*, pretrematic branch of the facialis; *pal*, ramus palatinus VII. (=great superficial petrosal); *sp.V*, spinal V. tract; *ta*, tuberculum acusticum (terminal nucleus for acustico-lateral system); *thm*, hyomandibular trunk (=great facial trunk of man); *Xg*, visceral vagus ganglion; *XI*, motor fibers for trapezius muscle, supposed to represent the accessory nerve.

tube and the adjacent ectoderm to form the neural crest, from which a part of the cranial and spinal ganglia and of the sympathetic system are to be derived. And in the head region farther laterally patches of thickened sensory epithelium are differentiated to form ectodermal placodes. These lie in two rows, one more dorsal, the suprabranchial series, and one more ventral, the epibranchial series (Fig. 1589). The latter are formed in intimate relation with the external openings of the gill clefts.

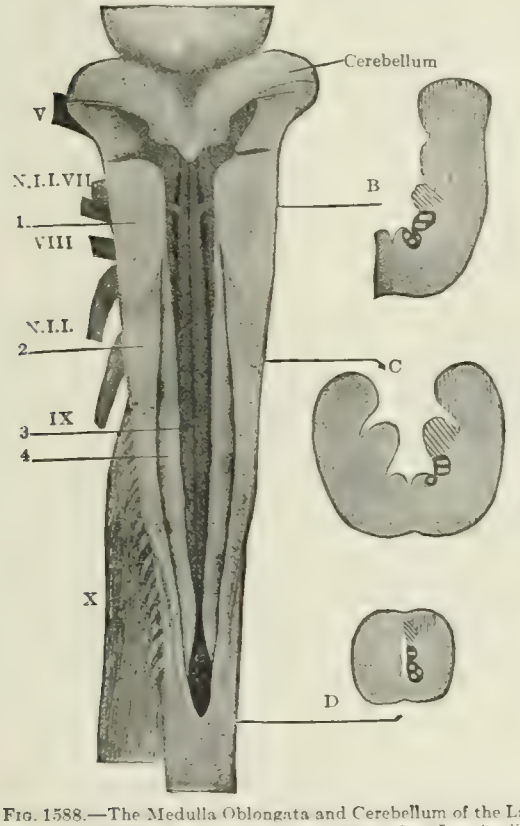


FIG. 1588.—The Medulla Oblongata and Cerebellum of the Lake Sturgeon (*Acipenser rubicundus*), to Show the Longitudinal Columns which are Developed as Centers for the Four fundamental Functional Systems of the Peripheral Nerves. A dorsal view with the chorioid plexus of the fourth ventricle removed. *B*, *C* and *D*, sketches of sections at the levels indicated by the reference lines. The dark area with the light circles is the somatic motor column, continuing the ventral horn of the spinal cord. The dark area with rectangular spaces is the visceral motor column, continuing the lateral horn of the spinal cord. The area with oblique cross hatching is the visceral sensory column, or lobus visceralis, containing both general visceral and gustatory centers. The area with vertical cross hatching is the somatic sensory column, containing below the general cutaneous centers and above the special somatic sensory nuclei (tuberculum acusticum and lobe of the lateral line). (After Johnston.) 1. Lobus lineæ lateralis; 2, tuberculum acusticum; 3, fasciculus longitudinalis medialis; 4, lobus visceralis.

In the trunk region the neural crests become segmented and their cells crowd together in each segment and migrate ventrally (Fig. 1592). Some cells are directly transformed into spinal ganglion cells, others migrate outward to form sheath cells of the peripheral nerves, while still others enter the sympathetic nervous system. In the head the development of the cranial nerve ganglia is much more complex. The neural crest, as in the trunk, becomes segmented and contributes important components to the cerebral ganglia. Rudiments of the neural crest extend forward beyond the trigeminus ganglion, probably representing vestiges of segmental nerves which have disappeared in the course of vertebrate evolution. Figs. 1590 and 1591 illustrate forms taken by the neural crest in two species of fishes, and Figs. 1592 and 1593 in human embryos.

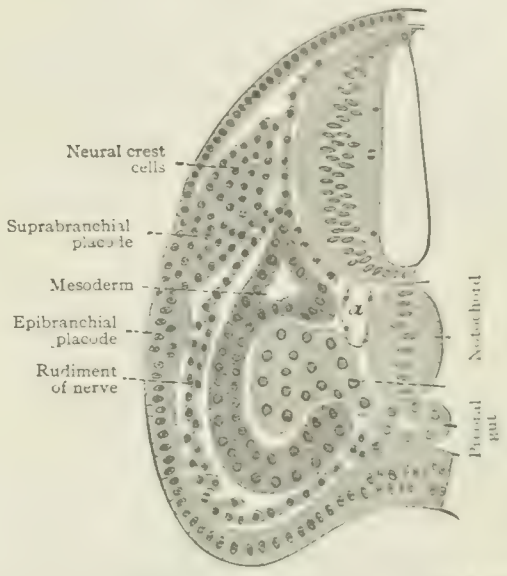


FIG. 1589.—Transverse Section Through the Head of a 7-day Embryo of *Petromyzon* in the Region of the Trigeminus Ganglion. (After von Kupffer)

During the process of differentiation of cells of the cranial ganglia from the neural crest the suprabranchial and epibranchial placodes are undergoing an independent differentiation in the ectoderm, and finally cells are proliferated from the placodes which

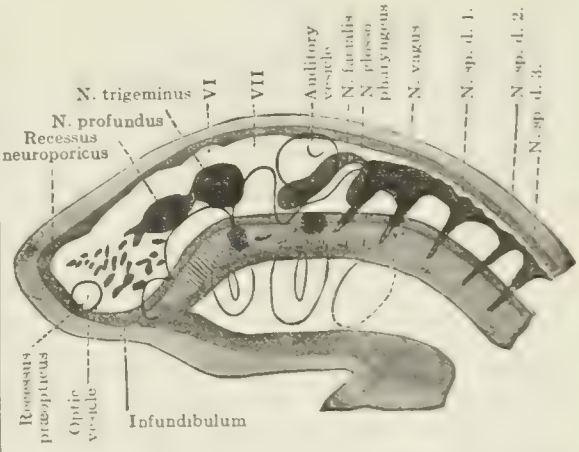


FIG. 1590.—A Diagram of the Head of the Embryo of *Petromyzon* at a Stage when Two Gill Clefts are Open and the Neural Crest is Segmented into the Rudiments of the Cranial Ganglia. From the left side. The suprabranchial (dorsolateral) placodes are indicated by vertical and horizontal cross lines, the epibranchial placodes by oblique lines. (After Koltzoff, from Johnston's Nervous System of Vertebrates, P. Blakiston's Son & Co.)

enter into the ganglia of some of the cranial nerves. The exact rôle played by placodal cells in the formation of the cerebral ganglia is not in all cases clear and it appears that there is considerable diversity among different species of vertebrates in this respect.

It is evident that in the head, as in the trunk, the systems of unspecialized components are derived from the neural crest. The researches of Landacre have further shown that the ganglion cells of the specialized visceral sensory system (gustatory neurones) are derived, apparently wholly, from the epibranchial series of placodes. In other words, the visceral sensory ganglia of the VII., IX., and X. cerebral nerves have a two-fold embryological origin which is correlated with their two-fold composition, the ganglion cells of the general or unspecialized visceral sensory component arising from the neural crest, while those of the specialized visceral sensory (gustatory) component come from the epibranchial placodes. After these placodes have thus contributed cells to the visceral ganglia they disappear.

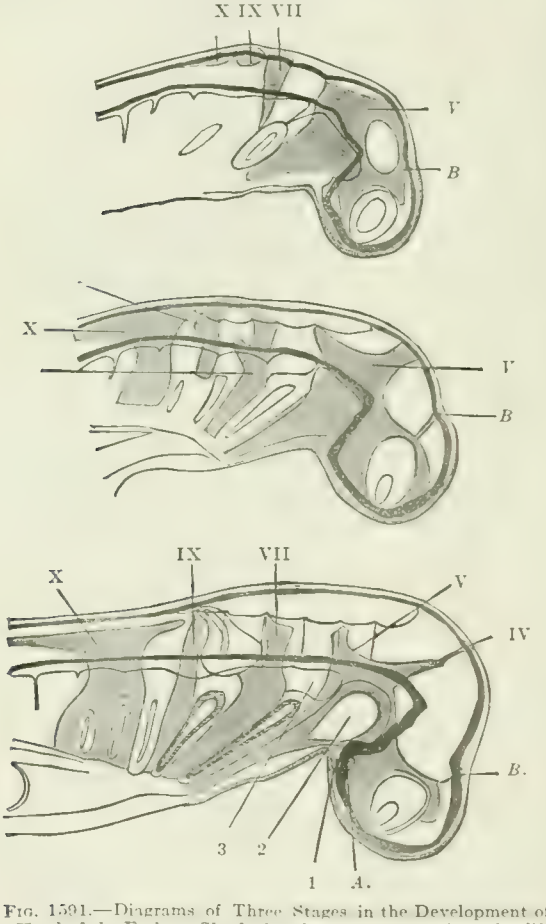


Fig. 1591.—Diagrams of Three Stages in the Development of the Head of the Embryo Shark, *Squalus acanthias*, to show the differentiation of the neural crest into the cranial ganglia; *A*, 1, 2, 3, somites; *B*, nervus thalamicus. (After Neal, from Johnston's Nervous System, P. Blakiston's Son & Co.)

The suprabranchial placodes are also transient structures with one exception. The auditory vesicle arises by the invagination of one member of this series. In the catfish (Ameiurus), where these relations have been most carefully studied, the ganglion of the VIII. nerve is proliferated from the auditory vesicle, the vesicle then differentiating into the membranous labyrinth with its contained areas of sensory epithelium, etc. The lateral line ganglia in the catfish arise partly from the auditory vesicle (lateralis IX. ganglion), partly from the suprabranchial placodes and partly from an undifferentiated lateral mass of cells which probably contains the representatives of the suprabranchial placode and neural crest. Further research is needed to determine the full significance of the suprabranchial series of placodes, but the special somatic sensory organs of the internal ear (and at least a part of the lateral line ganglia in fishes) take their origin from this source, while the general somatic sensory ganglia of the cutaneous systems are wholly derived from the neural crest, as in the case of the spinal nerves.

The olfactory organ arises as a sensory placode, from which neuroblasts migrate inward to form the

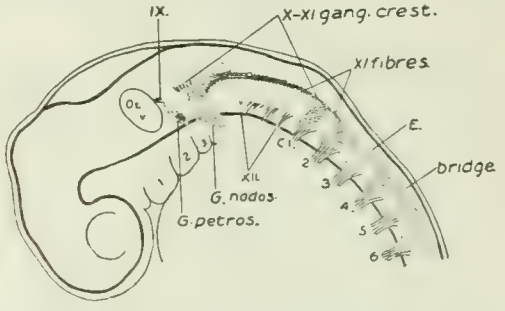


Fig. 1592.—Reconstruction of a Part of the Peripheral Nerves of a Human Embryo of 4 mm. (Hertwig's collection, No. 137.) × 16.7.

The neural crest in the trunk region has begun to segment into spinal ganglia (*E*). In the head region the cerebral ganglia of the IX., X., and XI. nerves are indicated. *Ot.v*, ear vesicle. (After Streeter, Am. Journal of Anatomy.)

ganglion of the nervus terminalis (Brookover), but the relations of this placode to those lying farther back are still undetermined. The cell bodies which give rise to the fibers of the olfactory nerve remain permanently at the surface in the olfactory epithelium.

The analysis of the cranial ganglia into general or unspecialized systems derived from the neural crest and special sensory systems derived from ectodermal placodes is most clearly evident in fishes, but similar placodes are known to occur in human embryos

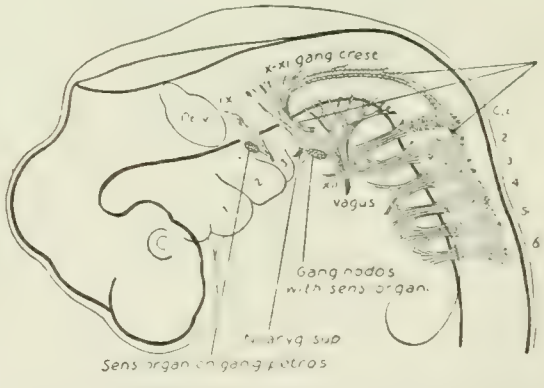


Fig 1593.—Reconstruction of the Nerves in the Occipital Region of a 7 mm. Human Embryo (Mall's collection, No. 2), which shows sensory placodes in connection with the ganglion petrosum and the ganglion nodosum. × 16.7. *Ot.v*, ear vesicle; *gang. crest*, neural crest. (After Streeter, Am. Journal of Anatomy.)

and the same fundamental relations probably prevail here. The interpretation of these data has been retarded by the failure of many investigators to take into account the diversity in the functional composition of some of the cranial ganglia. The recognition of the fact that the ganglia on some of the more complex cranial nerves contain two or more functional components clarifies the developmental history of the peripheral nerves in much the same way that the doctrine of nerve components has

assisted in the analysis of the medulla oblongata into functionally defined columns.

In mammals the ganglion on the V. nerve will probably prove to be derived from the neural crest, these neurones belonging to the general or unspecialized somatic group and supplying chiefly the skin of the head. The semilunar or Gasserian ganglion represents at least two embryonic segments, which primitively contained respectively the profundus and the trigeminus nerves (cf. Fig. 1590). The VII. ganglion is probably derived partly from the neural crest (general visceral neurones) and partly from the epibranchial placode on the hyoid cleft (special visceral or gustatory neurones), these two components being indistinguishably fused in the geniculate ganglion on the portio intermedia of the VII. nerve, as found in the adult body. The ganglion cells on the IX. and X. nerves also have a two-fold origin, partly from the neural crest (general or unspecialized

In a four-millimeter human embryo (Fig. 1592) the neural crest is in process of differentiation into ganglia. In the cervical region of the spinal cord the segmental enlargements of the neural crest, which later become the spinal ganglia, are still connected by bridges of cells. The XII. nerve is here seen in its primitive relations as a series of motor rootlets which directly continue the ventral root series of the spinal nerves. The neural crest in this region is largely devoted to the formation of the XI. and X. ganglia. In a seven-millimeter embryo (Fig. 1593) all of the ganglia of the cranial nerves have been laid down and the epibranchial placodes connected with the IX. and X. ganglia are seen. Fig. 1594 illustrates a reconstruction of the roots and ganglia of a ten-millimeter human embryo, and Fig. 1595 shows the relations in a fourteen-millimeter embryo. In the latter figure the transitory ganglia on the XI. and XII. (Froriep's ganglion) nerves are clearly shown.

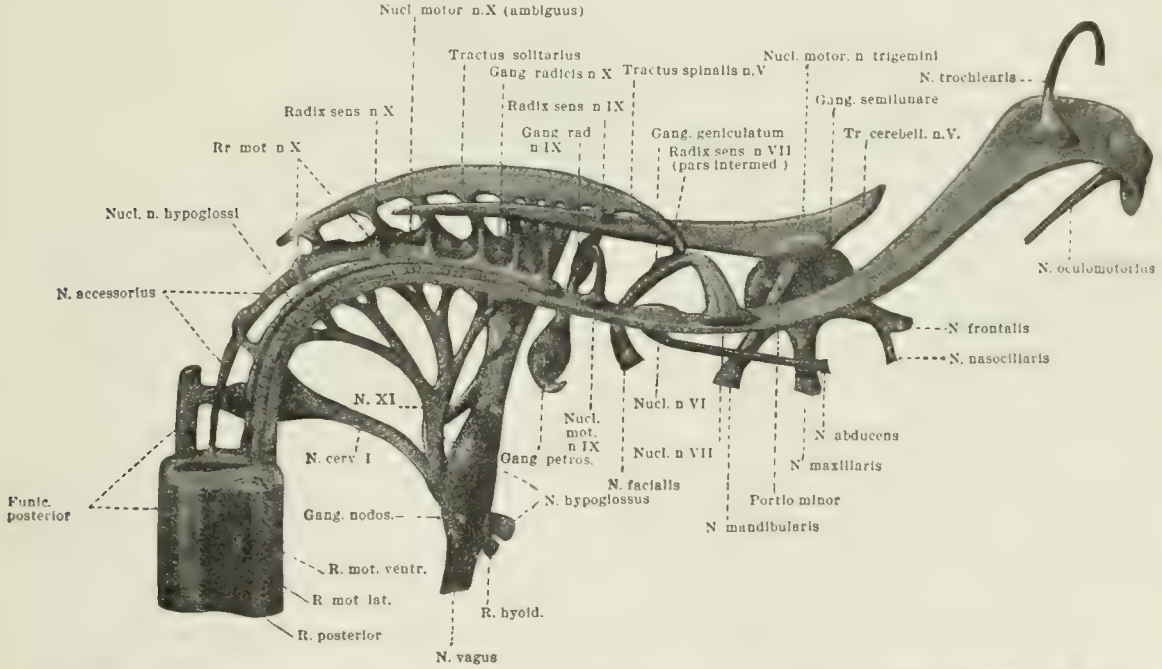


FIG. 1594.—Medial View of a Model of the Cranial Nerves of a 10 mm., Human Embryo (Huber collection, No. 3). A portion of the spinal cord is represented and above that everything is cut away excepting the sensory bundles and motor nuclei of the different nerves, and that portion of the marginal zone which is to form the funiculus ventro-lateralis. The somatic motor nuclei are seen to form a column which is the continuation of the ventral horn of the spinal cord. (After Streeter, Am. Journal of Anatomy.)

group) and partly from epibranchial placodes (special visceral or gustatory). The unspecialized sensory neurones of these nerves belong to two components: (1) general visceral neurones which in the adult are mingled with the special visceral neurones to form the visceral or trunk ganglia (ganglion petrosum IX. and ganglion nodosum X.); (2) general somatic neurones which in the adult form the root ganglia (ganglion superius, or jugulare, IX. and ganglion jugulare X.). The ganglion cells on the XI. nerve are derived from the neural crest and probably belong to the general visceral system. These ganglion cells, however, have only a transient existence, most of them disappearing before adult life. A small transient ganglion is found in human and other mammalian embryos on the XII. nerve (Froriep's ganglion). This is derived from the neural crest and is probably a vestige of the general somatic sensory ganglia on the nerves of the spino-occipital group from which the XII. nerve is phylogenetically derived.

Fig. 1596 illustrates the relations beween the IX., X., and XI., cranial and the spinal nerves of man, as determined by embryological and comparative studies. The root ganglia of the IX. and X. nerves (superior and jugular ganglia) and the transitory ganglion of Froriep on the XII. nerve are in part, at least, of somatic sensory type, homologous with the chief component of the spinal ganglia. The ganglia on the spinal accessory rootlets, like the g. petrosum IX. and the g. nodosum X., are of visceral sensory type. The motor fibers of the spinal accessory rootlets are in part general visceral in function for distribution with the vagus branches and sympathetic system, and in larger part special visceral motor for the striated musculature of the larynx region and for the trapezius and sternomastoid muscles. The latter muscles appear to be of mixed origin, chiefly from the branchial musculature, but partly from the myotomes, and they have a double innervation—visceral motor from the XI. nerve and somatic motor

from the cervical spinal nerves. By some anatomists the spinal portion of the accessorius is regarded as somatic motor in type.

The cells of the ganglia of the cranial nerves are at first bipolar, one process being directed centrally to form root fibers, the other peripherally. But in the course of further embryological development the two poles of the cell are gradually approximated and the processes finally coalesce, thus forming the T-shaped neurones which are characteristic of the cerebrospinal ganglia. Several stages in this process are illustrated in Fig. 1597. The ganglion cells of the VIII. cranial nerve, however, retain their bipolar character throughout life.

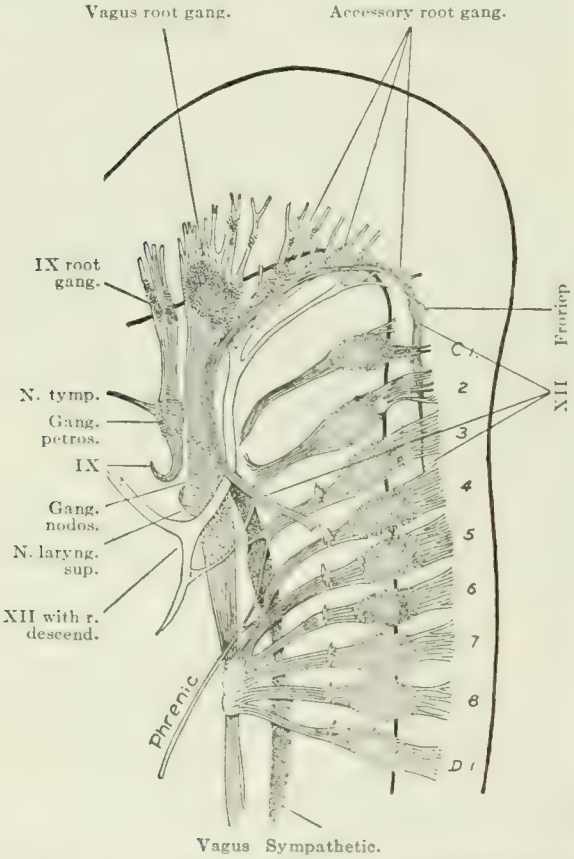


Fig. 1595.—Reconstruction of Some of the Peripheral Nerves of a 14 mm. Human Embryo (Mall collection, No. 144). × 16.7. (After Streeter.)

The nerves of special sense (I., II., and VIII. pairs) are described in special articles. In Fig. 1598 some of the general relations of the cranial and cervical spinal nerves are diagrammatically indicated, and in Fig. 1599 the details of the relations of their roots to the base of the skull. The central connections of the cranial nerves are briefly described in the article, *Brain, Anatomy.*

*III. Nervus Oculomotorius.*—The motor fibers of the third nerve arise from a group of nuclei in the floor of the aqueduct of Sylvius of the midbrain and emerge in several rootlets from the inner face of the crus cerebri. The somatic motor fibers supply the mm. rectus superior, inferior and internus, obliquus inferior and levator palpebræ superioris. The visceral motor fibers are of the preganglionic type and terminate in the ganglion ciliare, which they enter by the short root of this ganglion. The postganglionic neurones pass from the ciliary ganglion by way of the short ciliary nerves to the ciliary muscle and the constrictor muscle of the iris. The ciliary ganglion also receives a long root from the nasal branch of the V. nerve and sympathetic fibers from the cavernous plexus.

The eye muscles are provided with the usual muscular sense organs (muscle spindles and tendon organs), in addition to motor end plates, and these are supplied by sensory fibers which enter the brain with the III., IV., and VI. roots. These fibers constitute somatic sensory components of their respective nerves. Their

Fig. 1596.—Diagram Illustrating the Composition of the IX., X., XI., and XII. and First Spinal Nerves of Man. The somatic sensory component is shaded with horizontal lines, the visceral sensory with oblique lines, the somatic motor with round dots and the visceral efferent with dark rectangles. (After Streeter and Johnston, Spengel's Ergebnisse und Fortschritte der Zoologie.) 1, Accessory root ganglia; 2, root ganglion; 3, ganglion jugulare; 4, ramus auricularis; 5, ganglion petrosum; 6, ramus tympanicus; 7, ramus pharyngeus; 8, superior laryngeal nerve. The swelling between 7 and 8 in the ganglion nodosum.

central connections are unknown. The experiments of Tozer and Sherrington show that the musculo-tendinous sense organs of the eye muscles are not innervated, as formerly supposed, by the anastomotic filaments which the III., IV., and VI. nerves receive from the V. nerve, but that upon section of the ophthalmic branch of the V. the musculo-tendinous sense organs and their nerves are not affected. On the other hand, after section of the roots of the III., IV., and VI. nerves the musculo-tendinous sense organs and their nerves in the corresponding muscles, as well as the motor end plates, promptly degenerate.

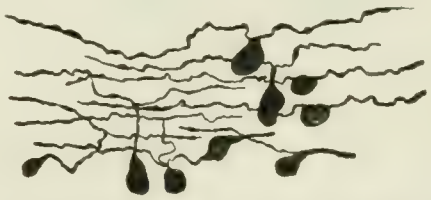

Fig. 1597.—Transformation of Bipolar into Unipolar Ganglion Cells in the Gasserian Ganglion of an Embryo Guinea-pig. (After Van Gehuchten.)

*IV. Nervus Trochlearis.*—The nucleus of the IV. nerve lies in the floor of the aqueduct of Sylvius just caudad to that of the III. nerve. The fibers curve outward, dorsally and backward to emerge from the dorsal surface of the brain behind the corpora quadrigemina, there to decussate completely in the valve of Vieussens, thence to run forward to supply the superior oblique muscle. It is joined by filaments from the sympathetic and from the ophthalmic branch of the trigeminus. Somatic sensory fibers are present in this nerve for muscular and tendinous sense organs of the superior oblique muscle.

*VI. Nervus Abducens.*—The VI. nerve arises from a nucleus in the floor of the fourth ventricle and pursues a direct course to the external rectus muscle of the eyeball. It receives minute filaments from the carotid plexus of the sympathetic and from the ophthalmic branch of the trigeminus. The VI. nerve also contains somatic sensory fibers for muscle and tendon sense organs in the external rectus muscle.

*V. Nervus Trigeminus.*—The composition and distribution of the V. nerve are remarkably constant throughout the vertebrate phylum. It supplies motor and sensory fibers to the muscles of mastication and mediates general sensibility of the face, nasal cavity, mouth, and teeth. It has two roots, the portio major, sensory, and the portio minor, motor. There is in addition the mesencephalic root, which in some lower vertebrates has a separate origin distinct from the other portions. In some animals this root appears to be combined with the portio major and in still others with the portio minor. In human embryos this root emerges from the brain with the portio major (Johnston), but most of its fibers are distributed peripherally with the motor branches of the trigeminus (Willems). The trigeminus ganglion (semilunar or Gasserian ganglion) is borne on the portio major, immediately distal to which the nerve breaks up into three divisions which give the nerve its name, the ophthalmic, maxillary, and mandibular nerves. The motor branches all arise from the nervus maxillaris.

(1) The ophthalmic nerve is wholly sensory (Fig. 1601). It communicates with the sympathetic, III., IV., VI., and VII. nerves. Its first branch is a recurrent meningeal twig for the tentorium, after which it divides into nasociliary, frontal and lacrymal branches. The nasociliary nerve furnishes the long root of the ciliary ganglion (a ganglion of the sympathetic system), the long ciliary nerves, twigs for the conjunctiva, lining of the nasal fossa and skin of the tip of the nose. The frontal nerve supplies the conjunctiva and skin of the upper eyelid and the forehead. The lacrymal branch innervates the lacrymal gland, conjunctiva and adjacent skin. (2) The maxillary nerve (Fig. 1602) is also wholly sensory, supplying the skin of the side of the face (cheek, temple, lower eyelid, nose, and upper lip), the mucous lining of the nose and upper part of the pharynx and the teeth of the upper jaw, and communicating with the sympathetic sphenopalatine ganglion. (3) The mandibular nerve (inferior maxillary) receives the remainder of the general cutaneous fibers and all of the motor fibers of the trigeminus roots. The motor fibers supply the following muscles: temporal, masseter,

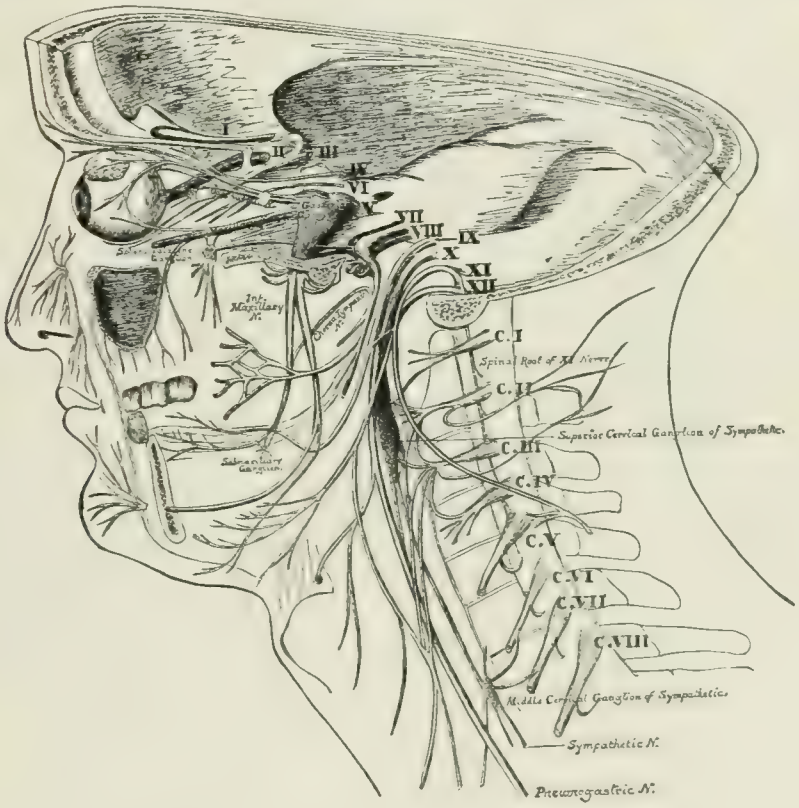


Fig. 1598.—General View of the Cranial Nerves. (Altered from Allen Thomson.)

external and internal pterygoid, tensor palati, tensor tympani, mylohyoid, and the anterior belly of the digastric. The sensory fibers supply the skin of the lower jaw, side of the head, external ear, external auditory meatus (in part), teeth of the lower jaw, anterior part of the tongue (general sensation only), mucous lining of the mouth and other parts adjacent. It communicates with the facialis and with the otic and submaxillary ganglia of the sympathetic system. The lingual branch is joined by the chorda tympani from the facial nerve and there has been much discussion regarding the exact courses of the fibers of these two nerves. The weight of evidence is clearly in favor of relegating the gustatory fibers all to the chorda and excluding this system from the trigeminus entirely.

The three divisions of the V. nerve supply sensory fibers to three well-defined areas of the skin of the head (cf. Fig. 1586). Fibers of musculo-tendinous sensibility go out with all of the motor branches and thus reach the trigeminus musculature. There are

also numerous peripheral anastomoses with those branches of the VII. nerve which supply the superficial musculature, probably for the innervation from the trigeminus of the musculotendinous organs of these muscles (Fig. 1610).

The V. nerve in some respects resembles the typical branchiomeric nerves rather closely, since it forks around the mouth as they do around the gill clefts, the special visceral motor component enters the posttrematic (mandibular) ramus, etc. But the other visceral systems characteristic of the branchiomeric root and probably also from the locus cœruleus farther forward. The fibers of musculo-tendinous sensibility are probably derived from the mesencephalic nucleus, whose cells represent elements of the neural crest permanently enclosed within the neural tube (Johnston, Willems, etc.). The cutaneous fibers terminate partly in the chief sensory nucleus at the level of the entrance of the root fibers and partly in the spinal V. nucleus, which extends from the chief sensory nucleus backward into the cervical region of the spinal cord. Clinical, experimental, and compara-

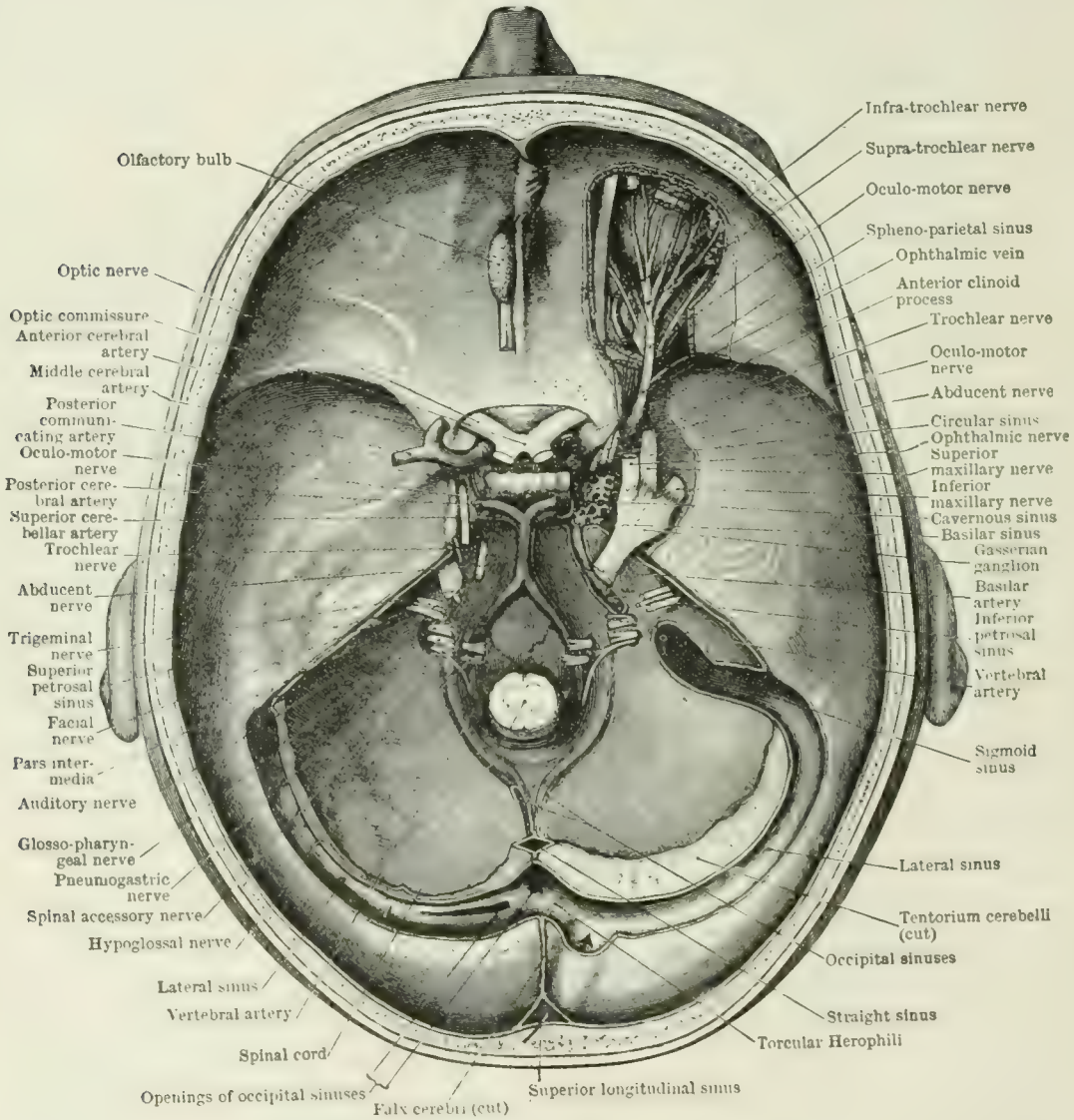


Fig. 1599.—The Base of the Skull, to Show the Dura Mater, Sinuses, Arteries, and Nerves. (From Cunningham's Anatomy.)

nerves are greatly reduced or absent. Few, if any, general visceral fibers occur in the V. roots, such of these fibers as are found in the peripheral branches being derived chiefly from various anastomoses with the sympathetic nervous system. The trigeminus is the great nerve of general cutaneous and muscular sensibility for the head, and with the enlargement of this system the other sensory components suffered reduction.

The motor fibers of the V. nerve are derived from the motor nucleus near the superficial origin of the tive data show that fibers which enter the spinal V. tract are so arranged that cutaneous fibers derived from the ophthalmic and maxillary nerves lie farther ventral in the tract, while the fibers from the mandibular nerve, especially those from the tongue and mouth cavity, lie farther dorsal (Fig. 1604). This brings the latter fibers into more intimate relation with the visceral sensory centers related to the fasciculus solitarius, and indeed some of the trigeminal root fibers pass directly into the fasciculus solitarius.

*VII. Nervus Facialis.*—In lower fishes the facialis

is a typical branchial nerve. The hyoid arch is a modified gill arch, as shown by perfect gills on its posterior face, and it is separated from the mandibular arch by the spiracular cleft, around which the facialis forks in just the same way as the other branchial nerves fork around their respective gill clefts (Figs. 1584 and 1605). The visceral sensory and motor components are arranged in typical branchiomeric fashion. The VI. nerve probably represents the somatic motor root of this segment. In cyclostome fishes there is also a somatic sensory (general cutaneous) root in the VII. nerve, but this disappears in all higher forms.

Fig. 1600.—View from Above of the Motor Nerves of the Eyeball and Its Muscles. (From Quain's "Anatomy.")

*a*, Upper part of the internal carotid artery emerging from the cavernous sinus; *b*, superior oblique muscle; *b'*, its anterior part passing through the pulley; *c*, levator palpebræ superioris; *d*, superior rectus; *e*, internal rectus; *f*, external rectus; *f'*, its upper tendon turned down; *g*, inferior rectus; *h*, insertion of inferior oblique muscle; II, optic commissure; II', part of the optic nerve entering the eyeball; III, common oculomotor; IV, trochlearis; V, large root of the trigeminus; V', small, or motor root; VI, abducens; I, upper division of III. nerve, giving twigs to the levator palpebræ and superior rectus; 2, branches of the lower division supplying the internal and inferior recti museles; 3, the long branch of the same nerve, proceeding forward to the inferior oblique muscle, and close to the number 3 the short root of the ciliary ganglion; this ganglion is also shown receiving from behind its long root, which has been cut short, and giving forward some of its ciliary nerves which pierce the sclerotic coat; 3', marks the termination of some of these nerves in the ciliary muscle and iris, after having passed between the sclerotic and choroid coats; 4, the trochlear nerve entering the upper surface ofh te superior oblique muscle; 6, the abducens nerve passing into the external rectus.

The chorda tympani represents the posttrematic branch, the Eustachian tube being the mammalian equivalent of the spiracular gill cleft of fishes. The facial trunk contains chiefly special visceral motor fibers for striated muscles, with a few visceral sensory fibers from the geniculate ganglion and probably some general visceral motor (preganglionic) fibers. The chorda tympani contains general visceral efferent fibers (chiefly preganglionic salivatory fibers for the submaxillary ganglion, whose postganglionic fibers supply the submaxillary and sublingual salivatory glands), and a larger number of special visceral (gustatory) fibers for taste buds on the anterior two-thirds of the tongue. Other visceral sensory fibers pass out from the geniculate ganglion by the great superficial petrosal nerve, which corresponds with the r. palatinus of fishes, and still other visceral connections are effected with the sympathetic system through the small superficial petrosal and other anastomotic twigs (Figs. 1606 and 1607).

The chorda tympani, accordingly, contains chiefly preganglionic salivatory fibers for the sublingual and submaxillary glands and special sensory fibers for the anterior part of the tongue. Its anastomosis with the V. nerve naturally follows from the fact that the facial and trigeminal fibers which combine to form the lingual nerve have the same area of distribution on the anterior two-thirds of the tongue, though different functions to perform there. The special visceral motor fibers of the facial trunk supply the hyoid musculature (stylohyoid, posterior belly of the digastric, and stapedius muscles) and an extensive system of superficial facial muscles.

The special visceral sensory, or gustatory, component of the VII. nerve is very large in fishes, whose

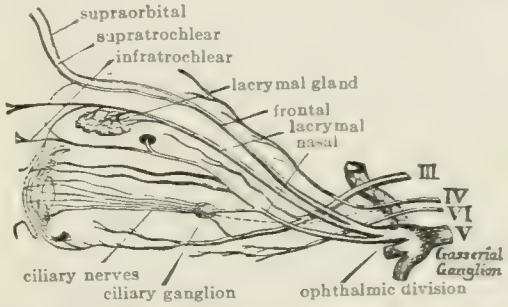


Fig. 1601.—The Nerves of the Left Orbit. (After Young, reduced.)

taste buds are very numerous and widely distributed. In some species, like the carp (Cyprinus) and catfish (Ameiurus), taste buds are found, not only very abundantly in the mucous membrane of the mouth, gills, and lips, but also distributed over the entire outer surface of the body. The cutaneous taste buds are always supplied by nerves arising from the geniculate ganglion (Fig. 1608), which here has important cutaneous branches reaching all parts of the body surface. These sense organs and nerves have nothing to do with the lateral line organs, which have an independent nerve supply belonging to the special somatic sensory (acustico-lateralis) system.

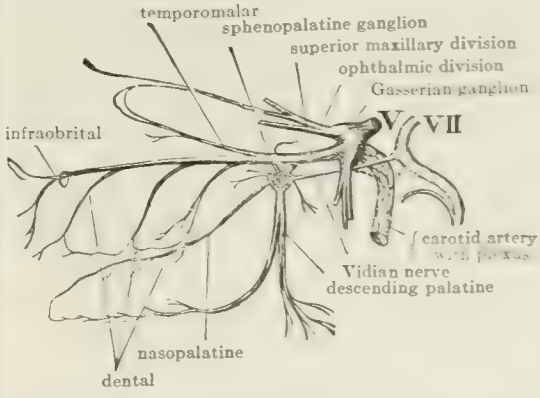


Fig. 1602. Plan of the Maxillary Division of the Trigeminus as seen from the Left Side. (Altered from Young.)

In fishes the motor root of the VII. nerve is relatively small and it supplies only the hyoid musculature, while the portio intermedia is often the largest nerve in the body. The course of evolution shows a remarkable metamorphosis of the facialis nerve (quite apart from the history of the lateral line nerves of fishes, some of which are associated with the facialis), from a branchiomeric nerve which is chiefly visceral sensory with a small motor component, to the human nerve which is chiefly motor and whose sensory component is so small that anatomists have often ignored it altogether. This metamorphosis is correlated with

the reduction of the gustatory system of the mouth and lips and the great enlargement of a system of facial muscles derived from the hyoid musculature. These muscles originally included as their most important element a constrictor system of the pharynx (sphinctor colli) and from this system the superficial mimetic musculature of the higher mammals has been gradually elaborated (Fig. 1609). The distribution of the more superficial branches of the human facial nerve and its anastomoses with the trigeminus are illustrated in Fig. 1610.

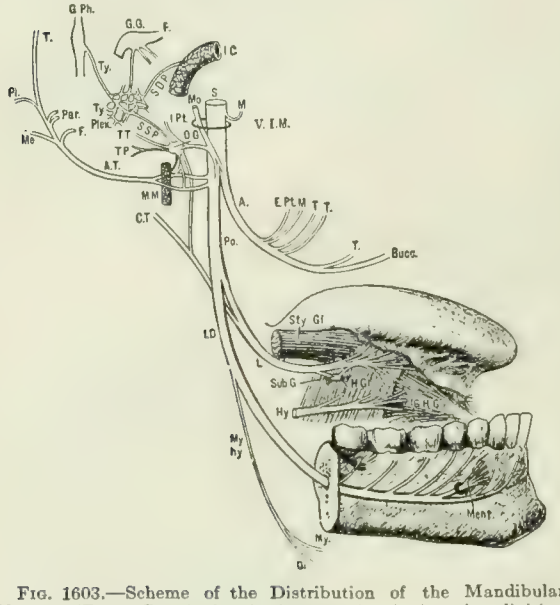


FIG. 1603.—Scheme of the Distribution of the Mandibular Nerve. (From Cunningham's Anatomy.) *A*, Anterior division of the n. mandibularis; *AT*, auriculotemporal nerve; *Bucc*, nerve to buccinator muscle; *CT*, chorda tympani; *Di*, nerve to anterior belly of digastric muscle; *EPt*, nerve to external pterygoid muscle; *F*, facial nerve; *F*, communication of auriculotemporal with facial nerve; *GG*, geniculate ganglion; *GHG*, m. genioglossus; *GPh*, IX. nerve; *HGl*, m. hyoglossus; *IC*, internal carotid artery; *ID*, inferior dental nerve; *IPt*, nerve to internal pterygoid muscle; L, lingual nerve; *M*, meningeal branch of *V.* nerve; *M*, nerve to m. masseter; *MM*, middle meningeal artery; *Me*, nerve to meatus of ear; *Ment*, mental nerve; *Mo*, portio minor V.; *My*, nerve to mylohyoid muscle; *My.hy*, mylohyoid nerve; *OG*, otic ganglion; *Par*, nerve to parotid gland; *Pi*, nerve to pinna of ear; *PO*, posterior division of n. mandibularis; *S*, portio major V.; *SDP*, small deep petrosal nerve; *SSP*, small superficial petrosal nerve; *Sty Gl*, m. styloglossus; *T*, temporal branch of auriculotemporal nerve; *TT*, nerve to m. tensor tympani; *T,T,T*, nerves to temporal muscles; *TP*, nerve to m. tensor palati; *Ty*, tympanic nerve; *Ty Plex*, tympanic plexus; *VIM*, nervus mandibularis.

The course of the fibers in the chorda tympani has given rise to much controversy. The study of lesions in the vicinity of the V. and VII. roots, whether experimentally or pathologically produced, has frequently yielded ambiguous results. In particular, many cases of surgical removal of the semilunar ganglion have resulted in disturbances of taste, from which it was inferred that gustatory fibers must reach the brain through the V. root. But a considerable number of carefully studied recent cases support the clear evidence from both embryology and comparative anatomy that the V. nerve has no connection with the specific gustatory organs, though its termini on the tongue may be sensitive to certain types of chemical stimulation not related with taste buds (Sheldon). Fig. 1601 illustrates the now generally accepted course of the specific gustatory fibers and some of the theoretical pathways which have been advocated by different neurologists.

The special visceral motor fibers of the VII. nerve arise from the motor VII. nucleus. The central localization of various groups of muscles within this nucleus has been experimentally determined by Van Gehuchten (Fig. 1612). The general visceral efferent fibers of the salivatory system arise from the nucleus salivatorius superior lying dorso-laterally of the chief motor nucleus. The general visceral sensory and the gustatory fibers enter the fasciculus solitarius and terminate in the nucleus associated with this tract.

*IX. Nervus Glossopharyngeus.*—In lower fishes this is the most typical branchiomeric nerve (Figs. 1583 and 1605), containing the characteristic visceral components, a general somatic sensory component for the overlying skin and sometimes a special somatic sensory component for lateral line organs, all distinct from other nerve roots. In Bdellostoma, Johnston is of the opinion that a somatic motor root is also present in the IX. segment, thus completing the typical segmental pattern, though this component is absent in all higher forms.

The human IX. nerve contains general and special visceral efferent fibers, general and special visceral sensory fibers and a general somatic sensory component. The general visceral efferent group are preganglionic fibers, chiefly for salivary secretion, passing through the tympanic and small superficial petrosal nerves and terminating in the otic ganglion, from which postganglionic fibers pass to the parotid salivary gland. Other preganglionic fibers may connect with the sympathetic system by other anastomosing twigs. The special visceral motor fibers innervate the stylo-pharyngeus muscle. The tympanic nerve corresponds to the palatine branch and

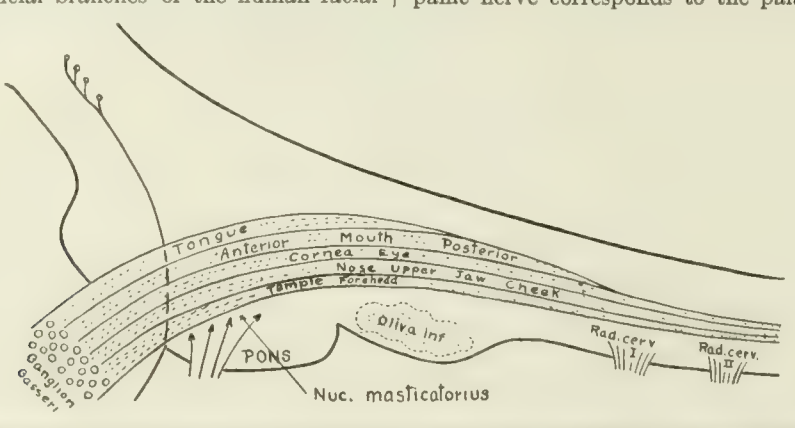


FIG. 1604.—Diagram of the Roots of the Nervus Trigeminus, to illustrate the arrangement of the sensory fibers, after the researches of Wallenberg and Marburg. (Modified from Edinger.)

the IX. trunk to the posttrematic branch of the nerve of the first gill cleft in fishes.

There are two ganglia on the IX. nerve, of which the larger (g. petrosum) belongs to the visceral sensory group. The smaller root ganglion (g. superius) probably, by analogy with lower forms, belongs, in part or wholly, to the somatic sensory component. The distribution of the general visceral sensory fibers tract, especially in an enlargement which extends dorsally to the ventricular surface under the lateral end of the trigonum vagi, the dorsal sensory nucleus. A portion of the IX. root fibers enter the spinal V. tract, here descending to form the most dorsal fibers of this tract (Ramón y Cajal). They probably terminate in the somatic sensory nucleus which accompanies the spinal V. tract (substantia gelatinosa

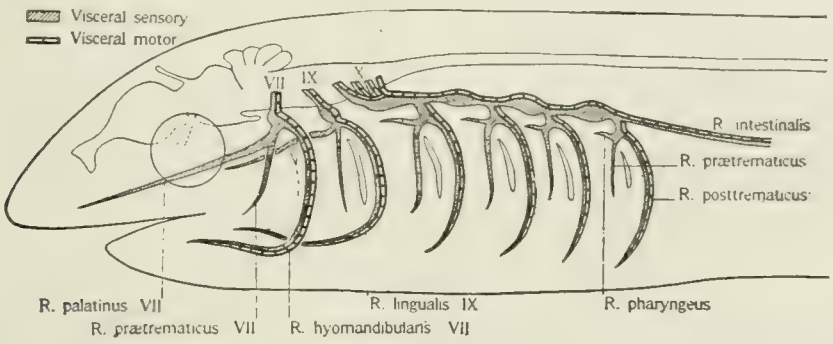


Fig. 1605.—Diagram of the Branchial Nerves of a Fish (*Selachian*). The V. nerve and the other somatic roots of the branchial region are omitted. (After Johnston, Spengel's Ergebnisse und Fortschritte der Zoologie.)

is not clearly determined, probably to the mucous lining of the tympanum, Eustachian tube, and pharynx. The special visceral sensory, or gustatory, fibers supply taste buds on the posterior third of the tongue. The somatic sensory fibers supply general sensation to the posterior third of the tongue and, by an anastomosis with the vagus, probably share in the distribution of the r. auricularis vagi.

Rolandi). These are probably fibers of the somatic sensory component.

*X. Nervus Vagus.*—This nerve represents a fusion of several branchiomeric units (cf. Figs. 1605, 1592, 1613, 1596). It has the same composition as the IX. nerve. The XII. nerve contains somatic motor fibers which belong to the vagus region.

The vagus communicates with the VII., IX., XI.,

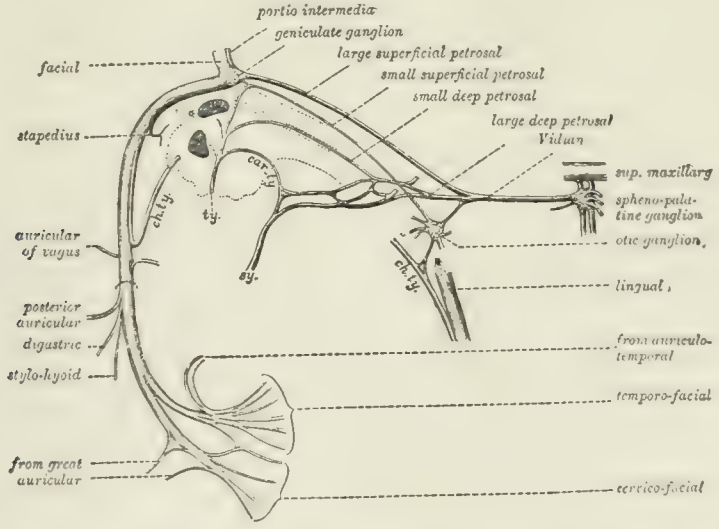


Fig. 1606.—Plan of the Facial Nerve. (After Thane, from Quain's "Anatomy.") *ch.ty.*, Chorda tympani, its middle part removed; *ty.*, tympanic branch of the glossopharyngeus; *sy.*, sympathetic on the internal carotid artery; *car.t.*, caroticotympanic nerve, passing between the tympanic nerve and the sympathetic in the carotid canal.

Centrally the special visceral motor fibers arise from the nucleus ambiguus. None of the preganglionic fibers arise from the dorsal motor IX. + X. nucleus, the salivatory fibers arising from a special nucleus salivatorius inferior which lies between the nucleus ambiguus and the dorsal motor nucleus. All visceral sensory fibers enter the fasciculus solitarius and terminate in the nucleus of cells which accompanies this

XII., first and second spinals, and the sympathetic. Its distribution is extensive, comprising branches to the dura mater, external ear, pharynx, larynx, heart, lungs, stomach, and other viscera. Throughout its entire extent the vagus is in frequent communication with the sympathetic nervous system and it seems to share many of its functions with the latter. It controls, more or less directly, the more important auto-

matic and vegetative functions of the body, such as circulation and digestion, and is thus of the most profound physiological significance.

The general visceral efferent fibers take their origin from the dorsal motor nucleus and ultimately distribute through the sympathetic system. The special visceral motor fibers arise from the nucleus ambiguus and supply striated muscles of the pharynx and larynx. The visceral sensory fibers arise from the ganglion nodosum and for the most part distribute to the external auditory meatus and back part of the pinna. As in the case of the IX. nerve, these somatic sensory fibers are probably the component of the root which enters the spinal V. tract, a condition which is known to prevail in several types of lower vertebrates.

*XI. Nervus Accessorius.*—The spinal accessory nerve consists of two parts, an accessory vagus part and a spinal part. The former contains general and special visceral efferent components and distributes with the vagus branches. The latter contains special

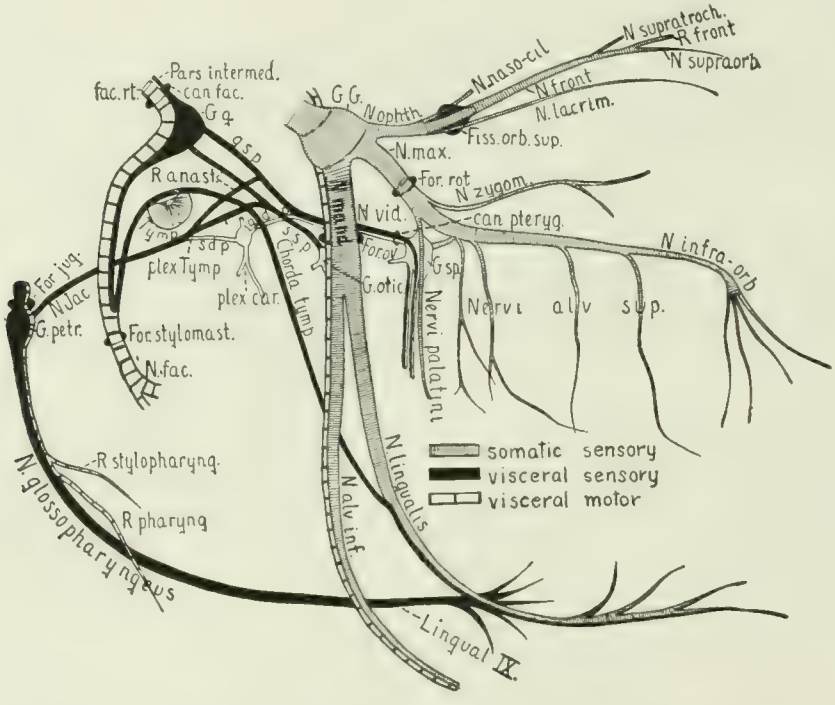


Fig. 1607.—Diagram of the Trigeminal, Facial, and Glossopharyngeal Nerves in Man, from the Right Side. The glossopharyngeal nerve, instead of appearing in its normal position in front of the facial, has been placed behind it. This is its true morphological position. This change necessitates the lengthening of Jacobson's nerve and a slight distortion of the tympanic plexus. The post-ganglionic sympathetic system is unshaded. It should be noted that the visceral nerves shown in black contain not only taste fibers but also several kinds of preganglionic sympathetic fibers of the efferent vasodilator and excito-glandular type. Many of these nerves undoubtedly contain also post-ganglionic fibers from the unshaded sympathetic ganglia. The somatic sensory fibers of the glossopharyngeal have not been indicated in the diagram. *Can fac*, canalis facialis; *can pteryg*, canalis pterygoideus; *chorda tymp*, chorda tympani; *fac rt*, motor facial root; *Fiss orb sup*, fissura orbitalis superior; *For jug*, foramen jugulare; *For ov*, foramen ovale; *For rot*, foramen rotundum; *For stylomast*, foramen stylomastoideus; *GG*, ganglion Gasseri; *Gg*, ganglion geniculi; *G otic*, ganglion oticum; *G petr*, ganglion petrosum; *G sp*, ganglion sphenopalatinum; *gdp*, great deep petrosal, from the carotid plexus to the great superficial petrosal to form the Vidian nerve; *gsp*, great superficial petrosal, from the geniculate ganglion to the sphenopalatine ganglion, probably carrying taste fibers for the soft palate through the palatine nerves; *N alv inf*, nervus alveolaris inferior; *Nervi alv sup*, nervi alveolares superiores; *N front*, nervus frontalis; *N infra-orb*, nervus infra-orbitalis; *N Jac*, nerve of Jacobson or the tympanic nerve; *N lacrim*, nervus lacrimalis; *N lingualis*, nervus lingualis for the anterior part of the tongue; *N mand*, nervus mandibularis V.; *N max*, nervus maxillaris V.; *N nasocil*, nervus naso-ciliaris; *N ophth*, nervus ophthalmicus V., *Nervi palatini*, palatine nerves for the soft palate; *N supraorb*, nervus supraorbitalis; *N supratroch*, nervus supratrochlearis; *N. vid*, vidian nerve; *N zygom*, nervus zygomaticus; *Pars intermed*, pars intermedia of Wrisberg, the sensory root of the facial; *plex car*, plexus caroticus; *plex tymp*, plexus tympanicus; *R anast*, anastomotic rami between the geniculate ganglion and tympanic plexus and the small and great superficial petrosal nerves, respectively; *R front*, ramus frontalis; *R pharyng*, rami of the glossopharyngeal nerve for the pharyngeal plexus; *R stylopharyng*, ramus stylopharyngeus IX.; *sdp*, small deep petrosal nerve from the carotid plexus to the tympanic plexus; *ssp*, small superficial petrosal, formed by the junction of the Jacobson's nerve through the tympanic plexus and the anastomotic branch from the geniculate ganglion; *Tymp*, tympanum. (After Sheldon.)

viscera through the sympathetic system. Centrally they enter the fasciculus solitarius and its nucleus. The special visceral sensory system is very extensively developed in the vagus of lower vertebrates, where taste buds are numerous in the branchial region. A few taste buds are found on the epiglottis and adjacent parts (J. G. Wilson), which are probably supplied by the vagus. The somatic sensory component has a separate ganglion (g. jugulare) and supplies most of the fibers of the ramus auricularis vagi for the skin of visceral motor fibers from the lateral horn of the spinal cord for the trapezius and sternomastoid muscles. The comparative morphology of this nerve has been already considered.

*XII. Nervus Hypoglossus.*—This nerve in man corresponds to the ventral roots of several segmental nerves of the posterior part of the branchial region of fishes. A vestige of its transient ganglion (of Froriep) rarely persists in the adult. The hypoglossus fibers emerge in from ten to fifteen rootlets, pass through the

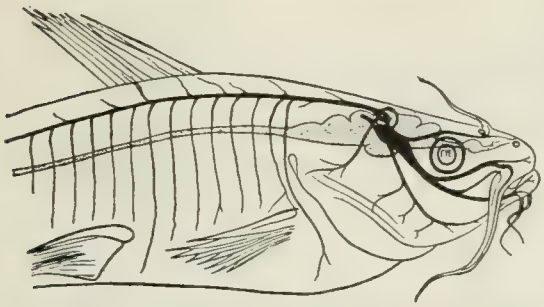

FIG. 1608.—The Cutaneous Gustatory Branches Arising from the Geniculate Ganglion of the Facial Nerve of the Catfish (*Ameiurus melas*). Projected upon the Right Side of the Body. Spinal cord and brain stippled. The geniculate ganglion, its roots and cutaneous branches are drawn in black; the branches of this nerve distributed to the mucous lining of the mouth cavity are omitted. Taste buds are found in all regions of the outer skin to which these branches are distributed.

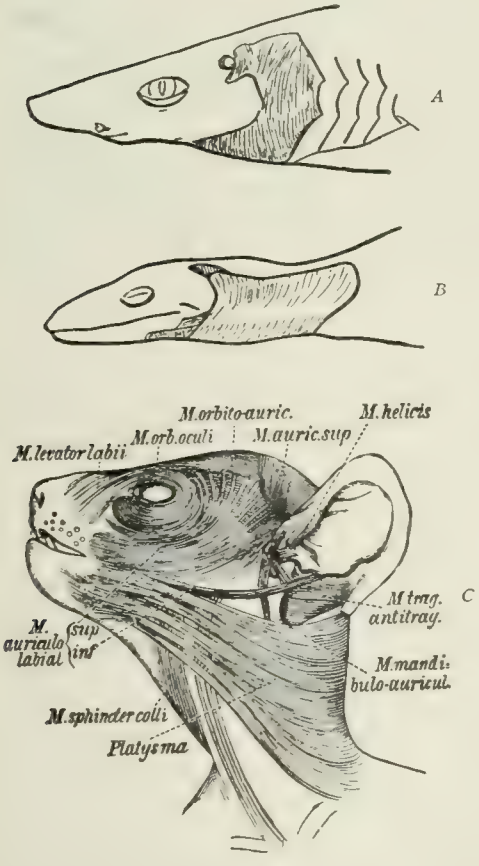


FIG. 1609.—Sketches Illustrating the Phylogeny of the Facialis Musculature. All of the muscles here indicated are innervated from the nervus facialis. The gradual expansion of this system from the branchial musculature of the hyoid arch (fishes) to a general constrictor system of the pharynx (reptiles), and finally the derivation of the superficial mimetic musculature from the latter system (mammals) are illustrated. (After Ruge.) *A*, Facialis musculature of a shark; *B*, of a lizard; *C*, of a generalized mammal (*Lepilemur*).

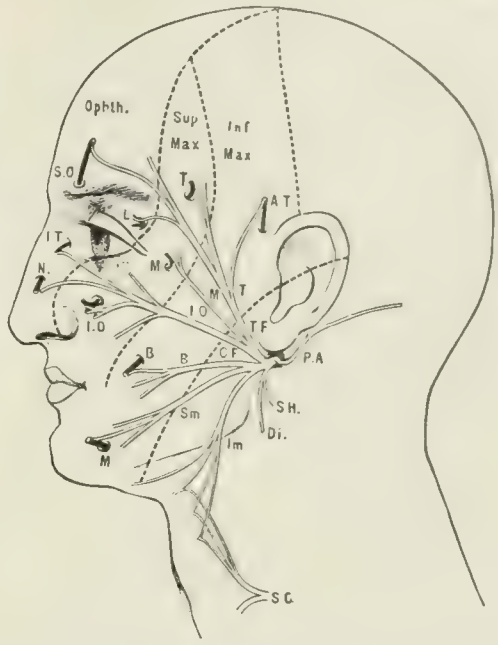


FIG. 1610.—Distribution of the Facial Nerve Outside the Skull, and its Communications with the Trigeminal Nerve On the Face. (From Cunningham's Anatomy.)

*Facial Nerve.*—*B*, Buccal; *CF*, cervicofacial division; *Di*, nerve to posterior belly of digastric muscle; *Im*, inframandibular branches; *IO*, infraorbital branches; *M*, malar; *PA*, posterior auricular nerve; *SH*, nerve to stylohyoid muscle; *Sm*, supramandibular; *T*, temporal; *TF*, temporofacial division.

*Trigeminal Nerve.*—*AT*, Auriculotemporal; *B*, buccal; *Inf Max*, inferior maxillary (mandibular) division; *IO*, infraorbital branches; *QT*, infratrochlear; *L*, lacrymal branches; *M*, malar; *M*, mental branches; *N*, external nasal; *Ophth*, ophthalmic division; *SC*, superficial cervical nerve; *SO*, supraorbital; *Sup Max*, superior maxillary division; *T*, temporal.

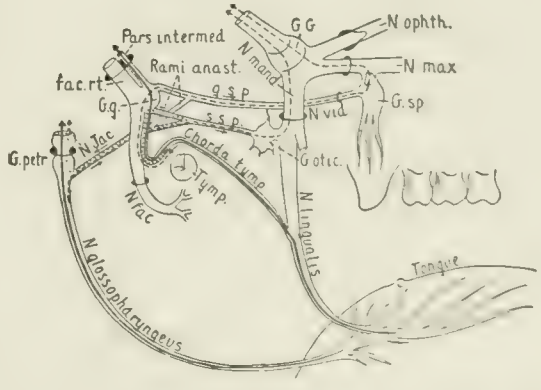


FIG. 1611.—Diagram Showing Some of the Various Courses Which have been Advocated for the Taste Fibers in Man. The courses advocated in this article are shown by heavy black lines; other suggested courses are indicated by broken or dotted lines. (After Cushing and Sheldon, Anatomical Record.) *fac.rt*, Motor facial root; *GG*, Gasserian ganglion; *Gg*, geniculate ganglion; *G.otic*, otic ganglion; *G petr*, ganglion petrosum; *G sp*, sphenopalatine ganglion; *g s p*, great superficial petrosal nerve; *N fac.*, facial trunk; *N Jac*, Jacobson's or the tympanic nerve; *N vid*, vidian nerve; *Rami anast*, anastomotic rami between the geniculate ganglion and tympanic plexus and the small and great superficial petrosal nerves respectively; *s s p*, small superficial petrosal nerve; *Tymp*, tympanum.

anterior condylar foramen, effect connections with the superior cervical ganglion of the sympathetic, the vagus, the first three cervical nerves and the lingual branch of the trigeminus. Its distribution is to the tongue musculature, a group of muscles which have migrated forward into their present position from the branchial region.

In the preceding discussion of the cranial nerves attention has been directed especially to their more general relations. The anatomical details are easily accessible in the standard textbooks. A functional analysis is essential, not only for the clinical, but also for the anatomical interpretation of the cranial nerves; and for this we are to a large extent dependent upon experimental and comparative data. In no departments of anatomy have the comparative and genetic methods yielded more valuable results than in the study of the peripheral nervous system.

C. Judson Herrick.

Fig. 1612.—Muscular Localization in the Facial Nucleus of the Rabbit. (After Van Gehuchten.) 1, Cells of the internal group related to the stapedius muscle; 2, cells of the internal group related to the muscles of the outer ear; 3, nucleus of origin of the fibers of the superior facial; 4, nucleus of origin of the fibers of the inferior facial, the inner portion related to the fibers of the inferior buccolabial branch, the outer portion to those of the superior buccolabial.

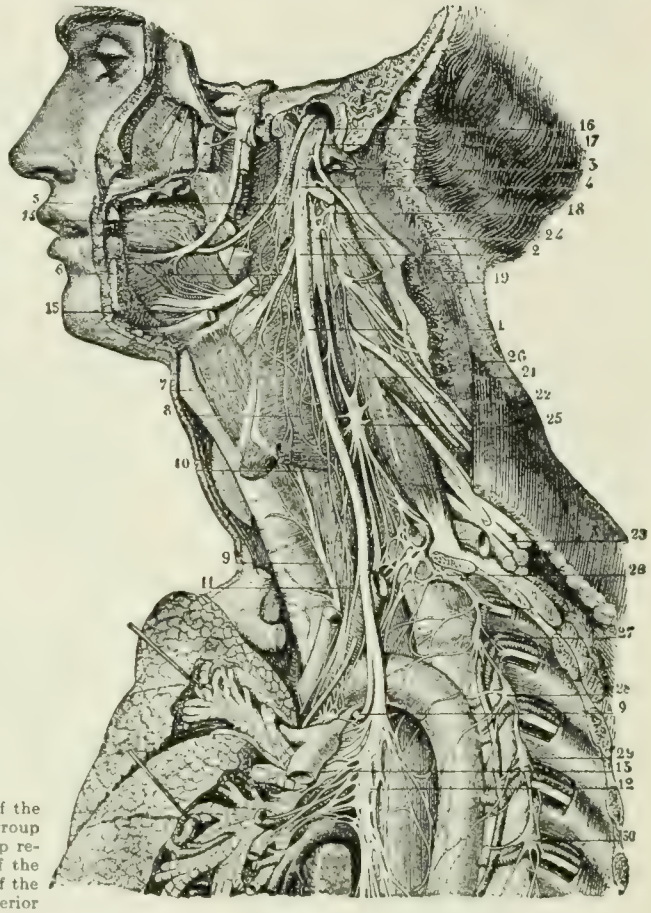


Fig. 1613.—The Distribution and Connections of the IX. and X. Nerves. (After Hirschfeld and Leveillé, from Quain's "Anatomy.") One-third. 1, Vagus nerve; 2, ganglion of its trunk; 3, accessory part of the spinal accessory; 4, union of the X. and XII. nerves; 5, pharyngeal branch of the vagus; 6, superior laryngeal nerve; 7, exterior laryngeal; 8, communication of the latter with the superior cardiac branch of the sympathetic; 9, inferior or recurrent laryngeal; 10, superior, and 11, inferior cervical cardiac branches of the vagus; 12, 13, posterior pulmonary plexus; 14, lingual branch of the mandibular branch of the V.; 15, distal part of the hypoglossal nerve; 16, glossopharyngeus; 17, spinal accessory nerve, uniting by its inner branch with the vagus, and by its outer passing into the sternomastoid muscle; 18, II. cervical nerve; 19, III.; 20, IV.; 21, origin of the phrenic nerve; 22, 23, V., VI., VII., and VIII. cervical nerves, forming with the first thoracic the brachial plexus; 24, superior cervical ganglion of the sympathetic; 25, middle cervical ganglion; 26, inferior cervical ganglion, united with the first thoracic ganglion; 27, 28, 29, 30, second, third, fourth, and fifth thoracic ganglia.

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**Craniocleidodysostosis.**—In 1903 this term was applied by Marie and Sainton to the condition of congenital defect of the clavicle associated with imperfect ossification of the cranial bones. Although a typical example had been observed by Morand as early as 1766, only forty-five cases could be collected from the literature in 1905 by Villaret and Francoz. In 1910 this number was increased to fifty-eight by Fitzwilliams, who added two cases of his own, making in all, sixty undoubted cases of this striking and rare condition observed to date. Fitzwilliams gives in his paper an analysis of these cases with full bibliography, and to his paper the reader is referred for fuller data (*Lancet*, November 19, 1910, p. 1466).

The chief facts relating to this condition given here are taken for the greater part from Fitzwilliams' paper.

Craniocleidodysostosis is an hereditary condition affecting those bones that develop wholly or partly in membrane. Of the sixty cases collected by Fitzwilliams six showed complete absence of the clavicles; in two cases the left clavicle alone was present; in three cases the right; in twenty-three cases the sternal end of the left clavicle and in twenty-seven cases that of the right clavicle was alone represented; in one case the acromial end of the left and in two cases that of the right clavicle was alone represented; in fourteen cases the left, and in seventeen cases the right clavicle showed both portions present but not united; in five cases the left, and in two cases the right clavicle showed union of the two portions but revealing its formation from two parts by angling, arching, or notching; in thirteen cases the left and in eleven cases the right clavicle showed a ligament prolonging the inner end outward.

The skull changes consist in deficient and defective ossification of the cranial bones that develop in membrane, namely those of the cranial vault. During infancy a large portion of the vertex remains in a membranous state. The fontanelles are extremely large, or united into one large fontanelle. This membranous area is further increased by an open metopic suture in front and by the absence of the interparietal portion of the occipital bone. As age advances this membranous area diminishes in size until the metopic suture, sagittal suture, and posterior fontanelle are obliterated by bone. This is usually completed by the end of the twentieth year. The anterior fontanelle also gradually shrinks, until a few years later it is completely closed. Its closure is sometimes greatly delayed and in some cases it remains open through life; in one of the cases collected by Fitzwilliams it was as large as the palm of the hand at forty-seven, and in another case was still unossified at the age of fifty-six. The delay in ossification of the membranous bones is associated with an increased bone formation in those areas already ossified. Six prominent bosses develop on the vertex, arranged in three pairs, one behind the other, corresponding to the frontal, parietal, and occipital bones. On the one side the three bosses are separated from those of the opposite side by a broad median furrow, which is deepest in front, and gradually becomes shallower as it extends backward, while each symmetrical pair is separated from the other by a transverse furrow, one of which corresponds to the coronary and one to the lambdoidal suture; of these the anterior is the better marked, but is broader, shallower, and less marked than the median furrow. The appearances are similar to those of the "hot-cross bun head" seen in congenital syphilis; and such changes may be mistaken for those of syphilis or rachitis, but the frontal bosses are more prominent and the median furrow deeper than in those conditions. The diameters of the skull are greatly changed, circumference, length, and breadth being all increased, but not proportionally, the increase in breadth being greater than that in length, the skull becoming brachycephalic in character. A large number of Wormian bones may be formed.

In all cases in which there are well-marked skull changes there are also pronounced malformations of the facial bones, the face usually being much smaller than normal, so that the contrast between the small face and the large head becomes very striking. The supraorbital ridges are very prominent and overhang the orbits, while the other facial bones are small and appear flattened or depressed. The nose is short and badly formed, and usually deviates to one side. Narrowness of the upper jaws, high arching of the palate and imperfect dentition also characterize the condition. The changes in the facial bones are regarded as secondary to the lack of development, and are not of primary pathological significance (Fitzwilliams). Other writers regard the changes in facial and cranial bones as due to the same cause (fetal rickets).

The defective development of the clavicles is also responsible for various changes in the musculature of the shoulder girdle. The sternocleidomastoid varies with the state of development of the sternal end of the clavicle. The clavicular portion of the trapezius is frequently absent. The anterior fibers of the deltoid are frequently lacking or represented by only a few fasciculi. The infraspinatus may also be feebly developed. In some cases the posterior bundles of these muscles are well developed. The clavicular head of the pectoralis major is usually present, but is imperfectly developed when the sternal portion of the clavicle is small; it may be completely absent; the chondrosternal portion remains normal. Some writers doubt the existence of the subclavius, although Scheuthauer found it hypertrophied and inserted into the under surface of the ligamentous substitute of the clavicle. The deeper muscles are unaffected. In spite of these muscular changes ordinary movements are not usually disturbed, some patients not noticing any disability. Other patients easily become fatigued in arms and shoulders.

Associated with the defective development of the cranium and clavicle are other disturbances of development. In the sixty cases, peculiarities in the shape of the sternum were noted in ten cases, scoliosis, lordosis, or kyphosis in eleven cases, prominence of the transverse processes of the cervical vertebræ in six cases, genu valgum in four cases, peculiarities of the hands in four cases, curvatures of the long bones in three, and flat and pigeon breasts in two cases each. Many of the patients were undersized and of generally poor development, while in some the intelligence seemed diminished, although this was not the case in the majority.

Gegenbaur, in 1864, emphasized the hereditary nature of craniocleidodysostosis, and although later Gross opposed this view, its correctness is affirmed by recent studies. Of the sixty cases collected by Fitzwilliams thirty-one were furnished by eight families alone, and this writer believes that if the other cases had been carefully examined the hereditary tendency would have been even more clearly demonstrated. Transmission is possible from parents of either sex, for five mothers and three fathers transmitted it directly to twenty-three children. Fitzwilliams could find in the records no observation of its transmission to the third generation, but explains this by the difficulty in obtaining any information as to the grandparents from the ordinary hospital patient. The sexes seem equally affected, twenty-eight cases were seen in females, twenty-six in males, in six no mention was made of the sex.

Various opinions have been advanced as to the etiology. Alcoholism, tuberculosis, syphilis, and rachitis have all been put forth as etiological factors, but with little probability in any case. The relations of the affection to achondroplasia may be helpful in explaining both conditions; in craniocleidodysostosis the membranous bones are affected, while in achondroplasia there is defective development of those bones originating in cartilage. Fitzwilliams suggests that in both conditions the cause may be due to the presence or absence of certain chemical constituents that are necessary for the normal ossification of the membrane bones in the one case and the cartilage bones in the other, in much the same way that hemophilia must be due to an hereditary absence from or presence in the body of certain chemical constituents. Couvelaire advanced a similar view. He regarded hereditary craniocleidodysostosis as "the expression of a general taint with a predominance in certain osseous groups." Hart (*Lancet*, 1911, p. 124) believes the affection can be explained by Mendelian views, through the loss of the determinants of a Mendelian group of unit characters at the maturation of the ovum or

spermatozoon. The condition is transmitted because the primitive germ cells are derived from an early division of the zygote, and when the determinants are causal, it is transmitted with a probability result, because its determinants are arranged in the primitive germ cells and zygote according to a frequency law. Achondroplasia and brachydactylism may be transmitted in the same way.

Incidentally, the study of craniocleidodysostosis throws important light upon vexed anatomical questions. The question of the development of the clavicle has long been a disputed one. Gegenbaur maintained that the clavicle is a dermal bone and not a real part of the shoulder girdle, while Hoffmann and Goette regard the clavicle as primordial. The study of craniocleidodysostosis shows that there are several anatomical distinctions between the two ends of the clavicle, and that in the majority of cases the sternal end was developed to some degree, while the acromial end was absent. Also in those cases in which the outer portion is undeveloped a ligament usually continues the inner portion of the clavicle toward the scapula, but this ligament is usually attached to the coracoid process. Two elements are therefore indicated in the clavicle, the older cartilaginous portion from the sternal end to the coracoid process, represented in the adult bone by the inner two-thirds of the bone and the coracoclavicular ligaments, and a new and separate dermal ossification for the flat acromial end which stretches from the ligament outward to the acromion. Fitzwilliams holds that the basal center of the coracoid process has the oldest phylogeny, and that by entering into the formation of the glenoid fossa it shows itself to be the true coracoid element of the pectoral girdle. The study of this affection, therefore, shows that important morphological knowledge may be obtained by pathological and clinical observations as well as in the anatomical laboratory, and anatomy should profit by the lesson.

ALDRED SCOTT WARTHIN.

**Cranioencephalic Topography.**—In the study of what is commonly called *craniocerebral* topography, it should be clearly understood that we are to deal not only with the cerebrum, but also with the cerebellum, the ganglia of Gasser, and the brain's meninges or coverings; moreover, the dura mater contains the middle meningeal arteries, and those venous channels called lateral sinuses and superior longitudinal sinus, not to mention other structures of less conspicuous importance from the point of view of applied anatomy. Also in relation with the arachnoid membrane is the *cisterna magna*, the largest of the subarachnoidan spaces.

It would seem that the use of the term *cranioencephalic* topography would be more conducive to accuracy than the commonly employed expression craniocerebral topography. It may not be amiss to recall the fact that cranioencephalic topography must not be confounded with the cranioscopy of the phrenologists, a pseudoscience founded by Gall. Gall quite arbitrarily localized the different intellectual faculties in various parts of the brain, and attempted to establish a relation between certain irregularities or bumps on the surface of the skull and the parts of the brain in which were resident the intellectual faculties. It is now known that the irregularities and bumps of the external table of the cranial walls have no relation whatever with the inequalities of the internal table, and still less have they anything in common with configuration of the brain's various components.

The human skull varies greatly, in the details of its conformation, according to race, age, sex, and even stature, not to mention pathological variations. In no two individuals of the same race, age, sex, and stature are the skulls ever precisely alike; nor, under such circumstances, are the fissures and convolutions of the brain ever identical in pattern. The relations of the brain's convolutions and fissures to definitely chosen anatomical points on the surface of the skull or scalp vary in individuals of the same race, etc. Lastly, as the convexity or surface area of the brain is always less than the outer surface area or convexity of the skull, and still less than the surface of the scalp, lines drawn on the scalp cannot always correspond exactly to the fissures and convolutions of the brain.

In view of the preceding facts the well-informed anatomist knows that the anatomical lines used in cranioencephalic topography to locate fissures, convolutions, and areas of the brain are simply approximations—approximations that have been correlated from examinations of many brains and skulls. Fortunately, these approximations are found to be exceedingly useful as reliable guides in surgical anatomy. Practically, the surgeon uses the lines and points correlated by the anatomist, and overcomes the difficulties due to variations in individuals, by removing a greater area of the cranial wall than that indicated to him by the anatomist's lines and points as corresponding to the portion of the encephalon which he desires to expose. The brilliant results of modern cerebral surgery clearly proclaim the practical utility of the anatomist's approximations in cranioencephalic topography.

In order to acquire an adequate knowledge of cranioencephalic topography three important groups of facts are necessary, viz.,

1. A knowledge of the surfaces of the cerebral hemispheres and their more important fissures, lobes and convolutions; a familiarity with certain cortical areas or centers; and a knowledge of certain important blood-vessels in the outermost of the meninges of the brain.
2. A practical familiarity with a number of important landmarks of the skull.
3. A knowledge of the relation of the fissures, convolutions and centers of the brain, and of the blood-vessels of the dura mater, to the landmarks of the skull.

SURFACES OF THE CEREBRAL HEMISPHERE.—The right and left cerebral hemispheres are completely separated in front and behind by the *great longitudinal fissure* (Fig. 1614) but only incompletely in the middle where the fissure extends down deeply to the corpus callosum.

Each hemisphere presents three surfaces: the outer or lateral one is convex and in contact with the cranial vault; the inner or mesial surface is flat and forms one side of the great longitudinal fissure; the lower surface, or base, irregular in shape, rests on the base of the skull in front and on the tentorium cerebelli behind.

The surfaces are divided by fissures into lobes and the lobes by shallower grooves into convolutions or gyri. The great bulk of each hemisphere consists of white or medullary matter, covered externally by gray cortical matter, so that the bottoms and sides of all the fissures and grooves are lined with gray matter.

On the lateral surface of each hemisphere are found the following important fissures, lobes, and convolutions:

The *fissure of Sylvius* (*S*, *S'*, *S''*, Fig. 1615) begins on the base of the brain at a fossa (vallecula Sylvii) which contains the anterior perforated space and runs outward to the lateral surface. Here it gives off a short *anterior horizontal limb* which passes forward; then it divides into an *ascending limb* (*S''*) and a long *posterior horizontal limb* (*S'*) which runs backward and upward, its terminal portion turning upward markedly into the parietal lobe of the hemisphere. This fissure separates the *frontal* (*F*) and *parietal* (*P*) lobes of the cerebrum from the *temporal lobe* or temporosphenoidal lobe (*T*).

The *fissure of Rolando* or *central sulcus* (*C*) as a rule

commences on the mesial surface of the hemisphere and then reaches its lateral surface at the superomesial border a short distance behind the midpoint between the frontal and occipital poles of the cerebrum. It takes a more or less sinuous course downward and forward on the lateral surface of the hemisphere for a distance of about three and three-eighths inches, terminating above the middle of the posterior horizontal limb of the fissure of Sylvius. The angle which the fissure of Rolando makes with the mesial plane

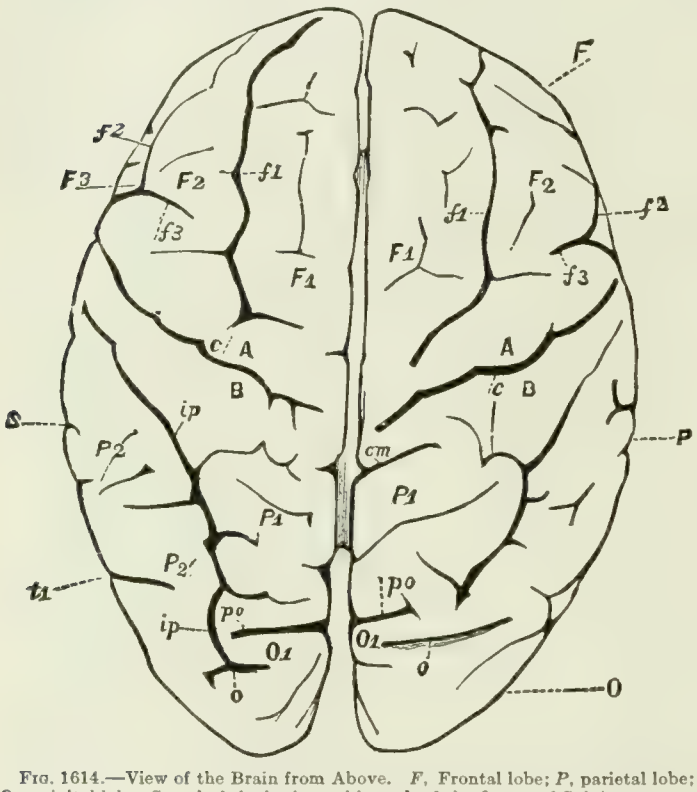


FIG. 1614.—View of the Brain from Above. *F*, Frontal lobe; *P*, parietal lobe; *O*, occipital lobe; *S*, end of the horizontal branch of the fissure of Sylvius; *c*, central fissure or fissure of Rolando; *A*, anterior central or ascending frontal convolution; *B*, posterior central or ascending parietal convolution; $F_1$, upper, $F_2$, middle, $F_3$, lower frontal convolution; $f_1$, superior frontal sulcus; $f_2$, inferior frontal sulcus; $f_3$, vertical fissure (sulcus precentralis); $P_1$, upper parietal lobule; $P_2$, lower parietal lobule, constituted, by $P_2$, supramarginal gyrus, $P_2'$, angular gyrus; *ip*, intraparietal sulcus; *cm*, calloso-marginal sulcus; *po*, parieto-occipital fissure; $t_1$, upper temporal sulcus; $O_1$, first occipital convolution; *o*, transverse occipital sulcus. (Ecker.)

of the skull is called the *Rolandic angle*. It has been variously estimated as from 67° to 74°. The fissure separates the *frontal lobe* in front from the *parietal lobe* behind.

The *parieto-occipital fissure* (*po*) is one continuous fissure found on both the mesial and lateral surfaces of the cerebrum. The latter cuts the superomesial border of the hemisphere in a transverse direction at a point about one and a half to two inches in front of the occipital pole. As a rule it is not more than about half an inch long, and very incompletely separates the parietal lobe in front from the *occipital lobe* (*O*) behind.

The lateral surface of each cerebrum thus presents *four lobes*—the *frontal*, *parietal*, *occipital*, and *temporal* or temporosphenoidal.

The frontal lobe (*F*) is seen to be the portion of the hemisphere lying in front of the fissure of Rolando and extending down to the fissure of Sylvius. The lateral surface of the frontal lobe is of special importance. It lies in front of the fissure of Rolando and extends down to the fissure of Sylvius. On it are seen three subordinate, but important, fissures, or sulci, viz., the *superior frontal* ($f^1$), the *inferior frontal* ($f^2$), and the *pre-Rolandic or precentral* ($f^3$) *sulci*. These subdivide the frontal lobe into the *superior* ($F^1$), *middle* ($F^2$) and *inferior* ($F^3$) *frontal convolutions*, and the *ascending frontal convolution* (*anterior central* or *pre-Rolandic convolution*) (*A*).

The parietal lobe (*P*) is bounded, on its lateral surface and superiorly, by the superomesial border of the cerebrum, anteriorly by the fissure of Rolando, posteriorly, in part, by the parieto-occipital fissure, and inferiorly by the posterior horizontal limb of the fissure of Sylvius. On the lateral surface of this lobe are seen two important subordinate fissures, viz., the *ascending parietal fissure* (*postcentral* or *post-Rolandic fissure*, and the *intraparietal fissure* (*ip*). The lower portion of the *ascending parietal fissure* is practically a continuation of the vertical portion of the other fissure found on this surface, viz., the *intraparietal* fissure (*ip*). Thus, this surface of the parietal lobe is subdivided into the *ascending parietal* convolution (postcentral or post-Rolandic convolution) (*B*), the *superior parietal convolution* ($P^1$), and the *inferior parietal lobule or convolution* ($P^2$, $P^3$). The latter convolution has two very important subdivisions, viz., the *supramarginal convolution* ($P^2$) around the upturned extremity of the posterior horizontal limb of the fissure of Sylvius, and the *angular gyrus* or *convolution* ($P^3$) around the upturned extremity of the parallel fissure ($t^1$) to be described immediately with the temporal (temporosphenoidal) lobe.

The lateral surface of the *temporal lobe* (T) is bounded in front and above by the fissure of Sylvius and by an artificial line which is drawn backward from the posterior horizontal limb of the fissure of Sylvius to the occipital lobe. Posteriorly it is bounded by the occipital lobe. On its lateral surface are found two fissures, viz., the *superior temporal fissure* ($t^1$) (or *parallel fissure* —because parallel with the posterior horizontal limb of the fissure of Sylvius), and the more or less interrupted *inferior temporal fissure* ($t^2$). These fissures subdivide this surface into the *superior temporal convolution* ($T^1$), more or less continuous with the supramarginal convolution; the *middle temporal convolution* ($T^2$) continuous with the angular convolution, and the *inferior temporal convolution* ($T^3$). The lateral surface of the *occipital lobe* (*O*) is partially delimited from the parietal lobe by the external portion of the parieto-occipital fissure and from the temporal lobe by an artificial line.

If the margins of the posterior horizontal limb of the fissure of Sylvius be separated there will be seen in the bottom of this fissure a triangular cluster of five or six convolutions (*gyri operti*) called the insula or *island of Reil*.

The mesial surface of each hemisphere (Fig. 1616) presents a number of fissures, two of which are important, viz., the *calcarine* (*oc*) and the *internal portion* of the *parieto-occipital* (*po*).

The *calcarine fissure* begins on the occipital pole by a bifurcated extremity and pursues a slightly arched course forward and ends below the thickened hinder margin (splenium) of the corpus callosum. Above the calcarine fissure is the cuneate lobe (*cuneus*) (*oz*); below it is a well-marked convolution called the *lingual lobule* ($T^5$). The *internal portion* of the *parieto-occipital fissure* is directed downward in a nearly vertical direction as a deep and conspicuous cleft. Its lower extremity runs into the calcarine

fissure a short distance behind the posterior extremity of the corpus callosum. It separates the *cuneus* behind from the parietal lobe (the *precuneus* or *quadrate lobe, Pl*[1]) in front.

On the mesial surface of the cerebrum is also shown the *calloso-marginal fissure* (*cm*). Above this fissure is shown the mesial portion of the fissure of Rolando (*c*, Fig. 1616), in front of which is the mesial portion of the ascending frontal convolution (*A*) and behind which is the mesial portion of the ascending part of the *parietal convolution* (*B*). Beneath the fissure of Rolando these two convolutions become continuous to form the *paracentral lobule* (*Pc*).

Cerebral Localization.—The *motor area* of the cortex, according to the newer investigations, embraces especially the ascending frontal or pre-Rolandic convolution (*A*, Fig. 1615), the posterior portions of the superior ($F^1$), middle ($F^2$), and inferior ($F^3$) frontal convolutions, and the paracentral lobule (*Pc*, Fig. 1616). It includes the following regions:

1. *Lower region:* the lower fourth of the pre-Rolandic convolution—the center for the musculature of the larynx, pharynx, tongue, mastication, and face. Small special centers are assumed to exist here for the lower and upper facial nerve.

2. *Middle region:* the middle two-fourths of the pre-Rolandic convolution—the center for the movements of the upper extremity. From below upward there is a further delimitation within this center of sub-centers for movements of the fingers, hand, arm, and shoulder.

3. *Upper region:* the upper fourth of the pre-Rolandic convolution, and the paracentral lobule—the center for the movements of the lower extremity. A further delimitation into particular centers for certain groups of muscles is frequently made; the experimental and clinico-pathological observations are so far from accord, however, that it is wise to omit any further subdivision into definite subcenters. The largest part of the superior frontal convolution, especially the region bordering the paracentral lobule and the upper fourth of the pre-Rolandic convolution, constitutes the center for the muscles of the trunk.

In the posterior part of the middle frontal convolution lies the center for the movements of the head and eyes toward the opposite side (conjugate deviation). According to some observers a second projection center for winking movements of both eyes is located in the angular gyrus.

*Sensory Area.*—The centers for touch, temperature, and pain, are found especially in the post-Rolandic convolution and the adjoining anterior part of the parietal lobe and even extend, possibly, into the pre-Rolandic convolution. The orientation- and space-sense, and position- and movement-sensibility are located in this region.

The *visual center* is located in the cuneus and more particularly within the cortex of the calcarine fissure, possibly extending into the lingual lobule.

The *auditory center* is located in the middle part of the superior temporal convolution and also in the transverse convolutions of the superior temporal convolution that are buried within the posterior horizontal limb of the fissure of Sylvius.

The *olfactory center* is located in the anterior part of the hippocampal convolution and probably adjoining this center is the *gustatory center*.

Speech Centers.—In right-handed individuals certain cortical areas are located on the lateral surface of the left cerebral hemisphere that constitute the center, or, rather, the centers of speech. They form really the *language zone*.

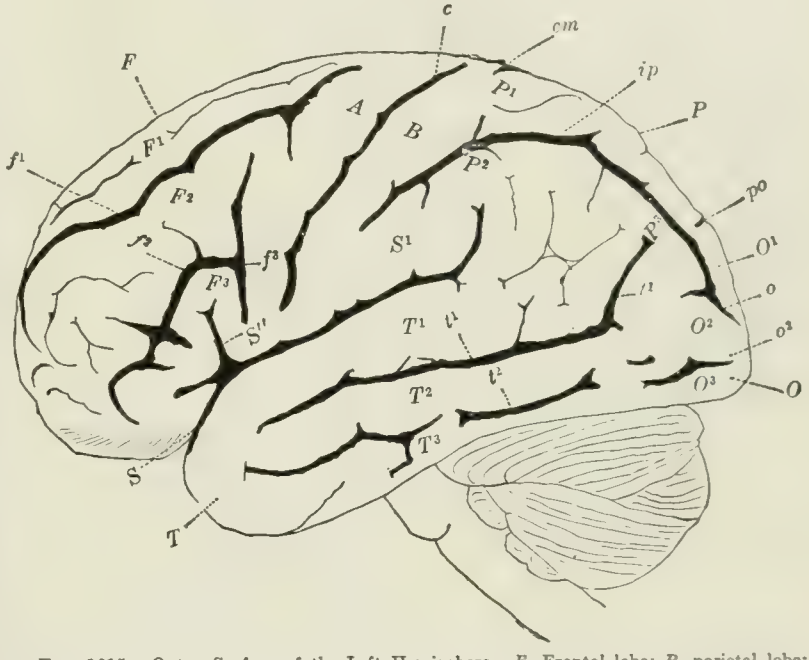


Fig. 1615.—Outer Surface of the Left Hemisphere. *F*, Frontal lobe; *P*, parietal lobe; *O*, occipital lobe; *T*, temporosphenoidal lobe; *S*, fissure of Sylvius; *S'*, horizontal, *S''*, ascending ramus of the same; *c*, central sulcus or fissure of Rolando; *A*, anterior central or ascending frontal convolution; *B*, posterior central, or ascending parietal convolution; $F^1$, superior, $F^2$, middle, and $F^3$, inferior frontal convolutions; $f^1$, superior, $f^2$, inferior frontal sulcus; $f^3$, precentral sulcus; $P^1$, superior parietal lobule; $P^2$, $P^3$, inferior parietal lobule, viz., $P^2$, supramarginal gyrus; $P^3$, angular gyrus; *ip*, interparietal sulcus; *cm*, termination of the calloso-marginal fissure; $O^1$, first, $O^2$, second, $O^3$, third occipital convolutions; *po*, parieto-occipital fissure; $o^1$, transverse occipital sulcus; $o^2$, inferior longitudinal occipital sulcus; $T^1$, first, $T^2$, second, $T^3$, third temporosphenoidal convolutions; $t^1$, first, $t^2$, second temporosphenoidal sulci. (Ecker.)

*a.* The *motor center* (Broca's center) lies within the posterior part of the inferior frontal convolution. It probably extends, also, to the adjacent part of the pre-Rolandic convolution and to the anterior part of the island of Reil.

*b.* The *auditory center* lies within the posterior third of the superior temporal convolution and the adjacent part of the supramarginal convolution.

*c.* The *visual center** lies within the angular convolution.

The Blood-vessels of the Dura Mater.—The cranial dura mater is composed of two layers intimately connected with each other. These two layers

* "It has been shown that injury to the lateral portions of the occipital lobes in monkeys does not produce visual defects *per se*, but that there are produced incoordinations in movements which involve the eye muscles. This would indicate that the lateral part of the calcarine type of cortex was the center for certain eye movement sensations. The relation of these facts to clinical phenomena in man with occipital lobe injury has not been established, but the possible relation of lesions at the occipital pole to deficiencies of coordination which involve the sensations from the eye muscles should be kept in mind." S. I. Franz: On the functions of the cerebrum: the occipital lobes. *Psychological Review*, Monograph No. 56, 1911, p. 118.

separate from each other along certain lines to form channels lined by endothelium. These channels are the *venous blood-sinuses* which receive the blood from veins coming from various parts of the brain.

The ones of special importance are as follows:

1. The *superior longitudinal* (*sagittal*) *sinus* (unpaired) commences in the anterior cranial fossa near the root of the nose where it communicates with the veins of the nasal cavity or with the angular vein. It passes upward, then backward, and finally downward in the sagittal plane of the skull, grooving the frontal, parietal, and upper part of the occipital bones. It passes slightly to the right side as it descends and ends at the level of the inion by becoming, usually, the right lateral sinus. Occasionally it turns to the left and ends in the left lateral sinus. Its termination is associated with a well-marked dilatation, the *torcular Herophili* (*confluens sinuum*).

2. There are two *lateral* (*transverse*) *sinuses*, one on each side. Each lateral sinus commences at the level of the inion (at the internal occipital protuberance), the right usually as the continuation of the superior longitudinal sinus and the left one as the continuation of the straight sinus. Each passes outward in a groove in the occipital bone and in the outer border of the tentorium cerebelli. It passes from the lateral angle of the occipital bone to the posterior inferior angle of the parietal bone, which it grooves; then leaving the tentorium it turns downward on the inner surface of the mastoid portion of the temporal bone; thence it passes to the upper surface of the jugular process of the occipital bone and turns forward and then downward into the jugular foramen to become continuous with the internal jugular vein.

The middle meningeal artery enters the cranial cavity through the foramen spinosum of the sphenoid bone to the middle cranial fossa. In this fossa it passes upward for a short distance in a groove on the great wing of the sphenoid, between the bone and the dura mater, and divides into anterior and posterior terminal branches. The anterior, the larger of the two terminal branches, passes upward along the great wing of the sphenoid, to the anteroinferior angle of the parietal bone, where it is sometimes inclosed in a distinct bony canal. It is continued upward a short distance behind the anterior border of the parietal bone almost to the vertex of the skull.

The posterior terminal branch passes backward from the great wing of the sphenoid to the squamous portion of the temporal bone, beyond which it ascends to the middle of the inner surface of the parietal bone.

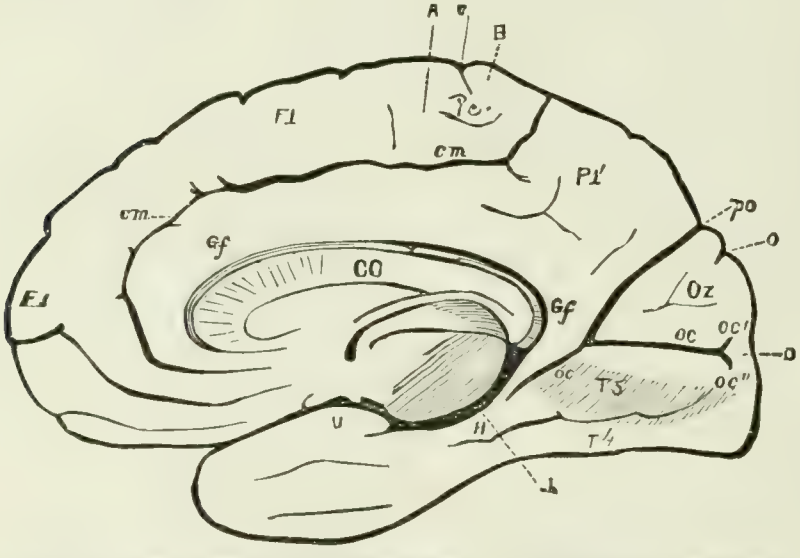


Fig. 1616.—Inner Surface of the Right Hemisphere. *CC*, Corpus callosum, longitudinally divided; *Gf*, gyrus fornicatus; *H*, gyrus hippocampi; *h*, sulcus hippocampi or dentate fissure; *U*, uncinate gyrus, *cm*, calloso-marginal sulcus; *F1*, median aspect of the first frontal convolution; *c*, terminal portion of the central sulcus, or fissure of Rolando; *A*, ascending frontal, *B*, ascending parietal convolution; *Pc*, paracentral lobule; *P1'*, precuneus; *Oz*, cuneus; *po*, parieto-occipital fissure; *o*, transverse occipital sulcus; *oc*, calcarine fissure; *oc'*, superior, *oc''*, inferior ramus of the same; *D*, gyrus descendens; *T4*, gyrus occipito-temporalis lateralis (lobulis fusiformis); *T5*, lingual lobule; *cf*, collateral or occipito-temporal fissure. (Ecker.)

Landmarks of the Skull.—The *glabella* (Fig. 1617, *G*), which may be prominent or flat, is on the vertical plate of the frontal bone and is situated in the median line or sagittal plane of the skull just above the root of the nose or the nasofrontal suture and between the supraorbital or superciliary ridges.

The *inion* (Fig. 1617, *I*) is a point of variable size and can usually be easily determined in the living, well down on the back of the head. It is the external occipital protuberance of the occipital bone.

The *pre-auricular point* (Fig. 1617, *E*) of the zygoma constitutes a valuable landmark. It is that part of the posterior root of the zygoma which lies immediately in front of the upper end of the tragus of the pinna or auricula of the external ear.

The upper edge of the zygomatic process of the temporal bone extends back over the external auditory meatus and is confluent with a ridge, the *supra-mastoid crest*, which curves backward and slightly upward. It serves to define the limit of the temporal fossa of the skull posteriorly.

The *postauricular point* (Fig. 1617, *Q*) is that point on the supramastoid crest a finger's breadth below, and immediately behind the upper attachment of the pinna or auricle of the external ear.

The *mastoid process* of the temporal bone is shown in Fig. 1617, *Z*.

The *external process* of the frontal bone is shown in Fig. 1617, just above *D*.

The *lambdoid suture* commences on each side of the mastoid portion of the temporal bone and inclines upward to meet the posterior extremity of the sagittal or interparietal suture. It connects the superior border of the occipital bone with the posterior borders of the two parietal bones. It is therefore also called the occipitoparietal suture.

The *coronal suture* commences at the extremity of the greater wing of the sphenoid (*H*) on one side and terminates at the corresponding point on the opposite side of the skull. It extends transversely across the vertex of the skull, connecting the frontal bone with the anterior borders of the parietal bones. It is the frontoparietal suture.

Many methods have been devised for mapping out the relations of the scalp to the cranial contents. From a clinical point of view, that introduced by Professor John Chiene, of Edinburgh, is a very simple and useful one (Fig. 1617). His method is as follows: The head being shaved, the *mid-point* (*M*) is located in the sagittal plane of the vertex from the glabella (*G*) to the inion (*I*); then the *three-quarter point* (*T*); and then the *seven-eighth point* (*S*). Next locate the *pre-auricular point* (*E*) on the root of the zygoma, and the *external angular process* (*D*) of the frontal bone. Having located these points join *D*

*T*, *E S*, and *D E*. Bisect *E S* at *V* and *D E* at *F*. Draw the line *F M* and also the line *V M*. Bisect *H L* at *K* and draw a line from *K* to *N* parallel to *H M*. Trisect *H M* at the points *R* and *P*. Draw a line from *T* to *V* and another from *V* to *I*. A finger's breadth (18 mm.) posterior to the *postauricular point* (*Q*) is the point *Y;* at the tip of the anterior border of the mastoid process is the point *Z*. A line drawn from *Y* to *Z* indicates the anterior border of the mastoid portion of the *lateral sinus*. The line *H M* corresponds to the *precentral fissures*, and may be called the *precentral line*. The points of its trisection correspond to the posterior extremities of the *superior* (*P*) and *inferior* (*R*) *frontal fissures*. The line *D T* is called the *Sylvian line;* it intersects the precentral line at the point *H*, which corresponds to the *Sylvian point* of the fissure of Sylvius, and also to the *anterior division* of the middle meningeal artery. *H A* corresponds to the anterior horizontal limb of the Sylvian fissure, and *H K* indicates the posterior horizontal limb of the fissure of Sylvius. This posterior limb of the Sylvian fissure terminates at the parietal eminence in the triangle *K O L* at the level of the temporal crest, indicating the position of the supramarginal convolution. The point *T* is the termination of the Sylvian line, and is somewhat in advance of the *parieto-occipital fissure*. The triangle *T V I* corresponds to the outer surface of the occipital lobe of the cerebrum. The line *I V* about corresponds to the tentorium cerebelli and the upper margin of the *lateral sinus*, while the line *V T* is a little above the *lambdoid suture*. The upper portion of the line *K N* corresponds to the *superior postcentral fissure*, but the lower part of the line is somewhat behind the *inferior postcentral fissure;* the line *K N* may be called the *postcentral line*.

The parallelogram *H K N M* overlies the ascending parietal and ascending frontal convolutions separated by the *central fissure* (fissure of Rolando), and hence corresponds to the cortical motor area (*area of Rolando*). The pentagon *F E V L H* outlines the *temporal lobe* of the cerebrum, except the apex; the latter is directed forward, downward, and inward about eighteen millimeters (a finger's breadth). About eighteen millimeters below the line *H L* is the superior temporal fissure (*parallel fissure*), which turns upward and terminates at *L*, thus indicating the position of the *angular gyrus*.

By drawing a line on the scalp from a point twelve millimeters behind the mid-sagittal point (*M*) downward and forward for 8.5 centimeters and at an angle of 67° to the sagittal line, the *fissure of Rolando* will be mapped out.

The inion *I* corresponds to the *torcular Herophili* and thus overlies the point of junction of the superior longitudinal, straight, lateral, and occipital sinuses. The groove for the lateral sinus may be mapped out by drawing a line from a point one or two millimeters above the inion, in a slightly curvilinear direction with the convexity upward, to the point *V* at the postero-inferior angle of the parietal bone. The point *V* forms the highest part of the convexity of the sinus. From this point the upper margin of the sinus follows the line *E V* for twenty-five millimeters; it then curves forward and downward to a point eighteen millimeters below and behind the center of the external auditory canal. The anterior border of the mastoid portion is indicated by the line *Y Z*.

The groove for the superior longitudinal sinus extends from the glabella to the inion. It increases in size from before backward and usually becomes continuous with the right lateral sinus. The edge of the trephine should be maintained at least eighteen millimeters from the mesial plane when the skull is opened over the posterior part of the vertex.

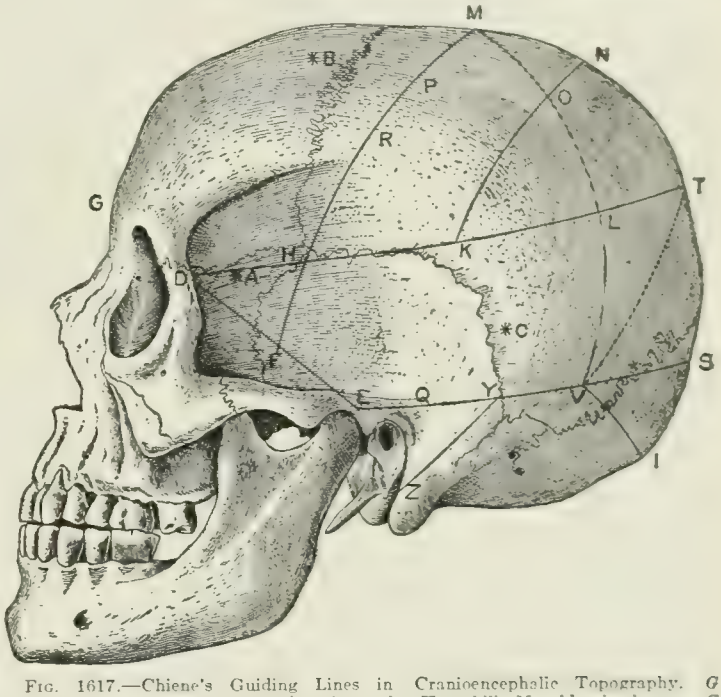


FIG. 1617.—Chiene's Guiding Lines in Cranioencephalic Topography. *G* glabella; *I*, inion and indicates site of torcular Herophili; *M*, mid-point between *G* and *I*; *T*, three-quarter point between *G* and *I* and overlies parieto-occipital fissure; *S*, seven-eighth point between *G* and *I*; *E*, preauricular point on root of zygoma; *Q*, postauricular point on supramastoid crest; *Y*, a finger's breadth behind *Q*; *V*, mid-point of line *E S* and marks highest convexity of lateral sinus; *Z*, near tip of anterior border of mastoid process; *D*, external angular process of frontal bone; *F*, mid-point on line *D E* and overlies point of bifurcation of middle meningeal artery; *H*, Sylvian point located by intersection of the Sylvian line *D T* and the line *F M*; this Sylvian point overlies the Sylvian point of the fissure of Sylvius and also the anterior division of the middle meningeal artery; *L* indicates angular gyrus and extremity of parallel fissure and is located by the intersection of line *D T* and line *V M*; *K*, mid-point of line *H L*; *H M*, precentral line and overlies precentral fissures; *K N*, line drawn from *K* to median sagittal plane parallel with *H M* and is the postcentral line; *H A*, anterior horizontal limb of the Sylvian fissure; *H K*, posterior horizontal limb of the Sylvian fissure; *O K L*, triangular area indicating parietal eminence, supramarginal convolution, and terminal part of Sylvian fissure; *R*, at the level of the temporal crest and on line of inferior frontal fissure; *P*, on line of superior frontal fissure; *T V*, courses a little in front of the lambdoid suture; *T V I*, triangular area indicating occipital lobe of cerebrum; *I V Y Z*, guiding lines for lateral sinus; below *I V Y Z* is the region of the cerebellar hemisphere; *F E V L H*, pentagon indicating temporal lobe of the cerebrum except the apex which projects a finger's breadth downward, forward, and inward from *F*; *H K N M*, parallelogram indicating cortical motor area (Rolandic area); **A*, site for opening subarachnoid space; **B*, Kocher's point for tapping the lateral ventricle; **C*, Keen's point for tapping the lateral ventricle; *Y Z*, indicating anterior limit of lateral sinus.

After the *middle meningeal artery* enters the middle cranial fossa through the foramen spinosum it runs outward and forward for about thirty-seven millimeters to the point *F*, which is located about a finger's breadth (eighteen millimeters) above the mid-point of the zygomatic arch. It here divides into anterior and posterior divisions. The anterior division passes, with a slight convexity forward, across the pterion upward and slightly backward behind the coronal suture. It gives off branches which ascend over the Rolandic area corresponding to the parallelogram

*H K N M.* This anterior branch corresponds to the lower two-thirds of the precentral line *H M*. In trephining over the lower part of the Rolandic area, especially over the cortical motor centers for the face and tongue, this anterior division will be encountered.

The *posterior division* of the middle meningeal artery passes backward almost horizontally toward the postero-inferior angle of the parietal bone. It may be indicated on the exterior of the cranial wall by drawing a line backward from the point *F* (which is eighteen millimeters above the mid-point of the zygomatic arch) parallel to the line *E V*.

When the calvarium is removed in the recent state the meningeal arteries will be found intimately adherent to the dura mater. The middle meningeal artery is the only one of them that is of surgical importance. In fractures of the skull the artery is frequently ruptured; the extravasated blood will generally be found between the cranial wall and the dura mater, and beneath the clot will be found the bleeding point of the artery.

To expose the anterior division of the artery the point of the trephine should be applied over the Sylvian point *H*.

To expose the posterior division of the artery the point of the trephine may be applied a finger's breadth (eighteen millimeters) above the zygomatic arch and the supramastoid crest between the points *E* and *V*.

To expose the main trunk of the meningeal artery between the foramen spinosum and the point of bifurcation at *F*, the trephine is applied immediately above the mid-point of the zygomatic arch. When the anterior division of the meningeal vessel is ruptured the extravasated clot presses upon the temporoparietal portion of the cerebrum and induces motor symptoms through pressure upon the centers for the face and arm; when the *frontal* branch of the meningeal's anterior division is wounded, the clot of blood is in the temporofrontal region of the cerebrum and produces pressure symptoms in the motor area for the face, and in addition, on the left side, involves Broca's convolution. Wounds of the meningeal's posterior division involve the occipitoparietal region and the pressure symptoms are sensory.

To reach the lateral hemisphere of the cerebellum the point of the trephine is placed over the mid-point of a line drawn from the inion to the tip of the mastoid process. In turning down the flap for this operation the mastoid emissary vein and the occipital vessels will be divided.

To tap the lateral ventricle at the commencement of its descending horn the point of the trephine should be placed a finger's breadth (eighteen millimeters) below the mid-point of the line *K L;* in this operation only one centimeter of brain tissue is penetrated through the posterior half of the first temporal convolution.

The asterisk at *C* overlies the site chosen by Keen for tapping the lateral ventricle; he makes an opening through the cranial wall thirty-one millimeters above Reid's base line (a line drawn from the lowest part of the infraorbital margin of the skull through the middle of the external auditory meatus to the back of the head), and the same distance behind the external auditory canal; he then passes the instrument into the brain tissue toward the summit of the auricle on the opposite side. The undistended ventricle will be reached at a depth of five centimeters from the surface.

The asterisk at *B* indicates the site selected by Kocher for draining the lateral ventricle. He makes an opening two fingers' breadth (thirty-one millimeters) in front of the point *P*, the instrument being directed backward and downward through the superior frontal fissure for a depth of four or five centimeters.

The asterisk at *A* overlies the site at which the point of the trephine is entered for draining the subarachnoid space; a small trephine should be used and the operator should be careful to keep in front of the middle meningeal artery.

The cisterna magna is reached by trephining a little above the foramen magnum and a little to one side of the external occipital crest so as to avoid the occipital sinuses.

Among the special methods of locating the fissure of Rolando that devised by Professor Chiene is the most simple and readily available. He folds a square piece of paper (Fig. 1618, *A, B, C, D*) on the diagonal line *A C*, so that the point *B* coincides with the point *D*, and the side *AB* with the side *AD*. Now evidently the folded piece of paper is triangular and has the shape *ACD*.

This triangular piece of paper is again folded in such a way that the border *AD* exactly coincides with the border *AC*. Now the paper is unfolded so as to present the original square condition, when three creases or

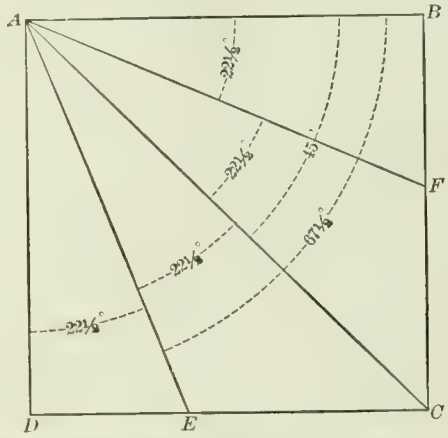


Fig. 1618.—Chiene's Method of Locating the Fissure of Rolando. The angle BAE equals 67½°.

lines will be revealed *AF, AC,* and *AE*, subdividing the right angle, *BAD*, into four equal triangles, each of 22½°. Cut away the triangle *EAD* (22½°) and there will remain the triangle *EAB* (67½°), which, for all practical purposes, is the angle of the fissure of Rolando.

That surface of the polygonal piece of paper (*ABFCE*) is applied to the head in such a manner that the point *A* is in the sagittal plane of the vertex of the head 12 millimeters (½ inch) behind the midpoint between the glabella and the inion; that the edge of the paper (*AB*) is carried forward in contact with the head and in the sagittal plane; and that the edge *AE* goes downward and forward on the side of the head. Then *AE* (for about three and three-eighths inches from *A*) will correspond with the fissure of Rolando.

Daniel Kerfoot Shute.

**Craniometry.**—See *Skull.*

**Craniotabes.**—*Synonyms:* Circumscribed craniomalacia; soft occiput; *weiche Hinterkopf, Weichschädel, Kautschukschädel.* The word is derived from the Greek *kranion,* skull, and the Latin *tabes,* a wasting.

Craniotabes may be briefly defined as a condition characterized by the presence of small and discrete, or diffuse and more or less extensive areas of softening and thinning in the bones forming the vault of the cranium.

History.—According to Marfan, the first contribution on this subject was made by Vimont in 1833. Heinrich Elsässer in 1837 reported a case of softening of the occiput which he observed in a young infant. Lucœ in 1839 was the next to write upon this subject. But the first extensive study of craniotabes was made in 1843 by C. L. Elsässer, who perceived its

close association with rickets. He differentiated two forms of craniotabes: *craniotabes posterior;* or that form which is confined to the occiput, and *craniotabes superior* (*Kautschukschädel*), in which the softening is confined to the parietal bones. Within recent years considerable attention has been paid to the study of craniotabes, and widely divergent views have been held as to its real nature and pathogenesis.

Description.—Two types of craniotabes may be distinguished. The more common form consists of discrete oval, circular, or lenticular patches of softened bone varying in diameter from one-quarter to one inch, and situated mostly in the upper or membranous part of the occipital bone and in the posterior part of the parietal bones. These patches may be detected by grasping the infant's head firmly with the thumb and three outer fingers of the right hand, and by exerting a varying degree of pressure with the index finger over different parts of the cranium. The thinned and softened areas of bone yield to the pressure and a crackling is elicited like that of stiffened parchment. Sometimes considerable pressure is necessary in order that the bone may be made to yield. All parts of the cranial vault should be explored, for the thinned and softened patches may be small, few in number, and widely scattered.

The less common type of craniotabes consists of softened areas of bone involving the free margins of the parietal and occipital bones and sometimes of the other cranial bones. The osseous thinning is most marked along the margins of the anterior and posterior fontanelles so that these appear to be greatly enlarged. The bones of the cranial vault are also widely separated from one another, so that one may run the finger along a more or less widened gap at the suture lines. Craniotabes is detected as one of the earliest signs of rickets, usually before the sixth month; it may precede all the other manifestations of rickets; and it may even constitute the sole external evidence of this disease. Craniotabes may even be detected in some infants at birth or a few days or weeks afterward. There is considerable difference of opinion as to the real nature of these early types of craniotabes. In premature infants an incomplete development of the cranial bones may be the cause of the presence of more or less extensive areas of softening of these bones, and even in infants at full term, physiological variations in development may account for the existence in some infants of softened cranial bones that are not to be regarded as the evidence of any coexisting or developing constitutional disease. True craniotabes has been differentiated from the spurious forms. True craniotabes is characterized as strictly of rachitic origin, and consisting of the softened patches described above. In addition to the areas of cranial softening that may be regarded as mere variations in cranial development, without any pathological significance, there may be recognized other forms.

Cleidocraniodysostosis (or craniocleidodysostosis) is a congenital anomaly in which there is a failure or retardation in development of bone formed in membrane, resulting in a deficiency in or absence of the clavicles and the bones of the cranial vault. In the various forms of encephalocele there is an absence of, or deficiency in, some part of the bony covering of the brain. Traumatism may be responsible for the persistence of certain depressions or softened areas in the cranium, and defects in the latter may be the result of trephining operations. Osteomalacia, osteoporosis, and osteogenesis imperfecta may be the cause of softening and thinning of the cranial bones. In pronounced degrees of hydrocephalus the bones of the cranial vault are not only widely separated from one another, but also considerably thinned as the result of the intense pressure to which they are subjected from within the cranium. Large areas of bone may be entirely absorbed from the same cause.

Etiology.—True craniotabes cannot be regarded as a disease entity. It is only a part of a general symptom complex. There is considerable difference of opinion as to the real factors that underlie the development of craniotabes. Most writers regard it as strictly a rachitic manifestation. There are others who believe that syphilis plays a predominating rôle as a causative factor, while others believe that a combination of rickets and syphilis is responsible for the cranial softening.

A. B. Marfan has made a most comprehensive study of this subject. He recognizes a congenital type of craniotabes which he regards as part of the clinical picture of congenital rickets. The cranial softening may begin during the latter weeks of intrauterine life, or any time before the fourth or fifth month of life. When the softened patches are congenital they are more apt to be situated toward the anterior part of the cranium, mostly in the neighborhood of the bregmatic and sagittal sutures. The spots of acquired craniotabes are found mostly along both sides of the lambdoidal suture and have a tendency to be symmetrical. They predominate, however, on the right side of the head. In order of frequency they appear on the occipital, parietal, temporal, and frontal bones. Variot has pointed out that craniotabes frequently coexists with plagiocephaly, a deformity of the cranium in which there is an undue prominence of one frontal boss and a depression of the parieto-occipital region on the corresponding side. This deformity is easily explained as the result of the infant's decubitus, which causes a flattening of the softened posterior portion of the cranium.

Elsässer, Kassowitz, and others correctly regarded craniotabes as a rachitic phenomenon. Lasègue attributed it to congenital debility. Parrot pointed out the association with prematurity, that he discerned in the congenital type of craniotabes. On the other hand be regarded the acquired type as a manifestation of inherited syphilis, belonging to the so-called rachitic period of this disease. J. V. Wichmann believes that craniotabes is a lesion of congenital origin; that it has no relation to rickets although in its later development it may coincide with this disease; and that it is either an anomaly or a physiological variation of the growth of bone. Wieland regards congenital craniotabes as a simple failure of ossification and the acquired type as a manifestation of rickets. He describes a congenital condition which he designates as "soft cranium" (*Weichschädel*), in which, as a mere biological variation, there is a delay in the deposition of lime salts in the bones of the cranium. The condition is of brief duration, the normal hardness of the cranial bones being attained at the end of two or three months. Holt has not observed craniotabes as a frequent symptom of rickets, but states that the former condition is more commonly noted when syphilis is associated with rickets.

Cautley believes that the small discrete areas of softening found during the first four months of life are of syphilitic origin. The same observer holds that the type of craniotabes affecting the free margins of the bones of the skull cannot be regarded as a definite proof of rickets, but that it is the result of an unsuitable diet. This type is attributed by him to delayed ossification or reabsorption of lime salts from the newly formed bone. J. F. Goodhart inclines to the view that craniotabes is of syphilitic rather than of rachitic origin although he alludes to the fact that it occurs in from 30 to 40 per cent. of all cases of rickets. He quotes Barlow and Lees who found that of 100 cases of craniotabes 47 per cent. were undoubtedly syphilitic, and also cites the observation made by Baxter that of the 23 per cent. of craniotabes in rachitic children, 75 per cent. were syphilitic. Goodhart reaches the conclusion that a combination of rickets and inherited syphilis is a most potent factor underlying the production of craniotabes.

G. F. Still, on the other hand, believes that craniotabes is only exceptionally related to syphilis. Of twenty-five consecutive cases of craniotabes there were observed by him only two undoubted cases of syphilis. Rickets was present in twenty of the remaining cases, and in the two syphilitic cases. Still emphasizes the importance of distinguishing between the absorption of bone that has already been formed, as occurs in true craniotabes, and the delay in the formation of bone, which may be one of the manifestations of syphilis. But even this phenomenon is regarded as exceptional in syphilis in which there is a tendency to an accelerated and exaggerated formation of bone. One important point in favor of the rachitic origin of craniotabes is the favorable effect upon the latter condition of antirachitic treatment. Following the administration of cod-liver oil in rachitic children craniotabes rapidly disappears. This therapeutic test furnishes an almost unassailable argument. If any further evidence is needed as to the rachitic basis of craniotabes this evidence is furnished by the close association of the latter with laryngismus stridulus. Of sixty-seven cases of this convulsive manifestation of rickets, only one showed none of the bony changes of the disease.

Pathology.—The macroscopic appearance of a skull which is the seat of craniotabes is characteristic. The softened areas of bone, whose distribution and size have already been mentioned, are best observed from the inside of the cranium. The absorption of bone begins first in the inner table of the skull and causes depressions whose edges form a gradual slope and merge into the surrounding bone. These depressions are oval, round, lenticular, or irregular in shape. They vary in depth according to the intensity of the rachitic process. The absorption of bone may involve only the inner table, or this together with the diploë, or the entire thickness of the cranium. In the last case there results an opening or operculum which is covered by a fibrous layer consisting of a fusion of the periosteum and dura mater. The extent and degree of thinning of the skull may best be determined post mortem by removing the vault of the cranium and examining it from the inside against a strong light, in which case the thinnest portions of bone will appear to be the most transparent. The inner surface of the cranial vault will also exhibit the depressions caused by the absorptive process. In pronounced cases the entire inner surface of the calvarium has a trabeculated appearance, the ridges between the depressions constituting the unaffected portions of bone. Parrot compared this surface with that of a map in relief. Marfan observed that the ridges and depressions correspond to the fissures and convolutions of the brain.

The pathological changes occurring in the areas of craniotabes are identical with those that take place in other bones as a part of the rachitic process. These changes are summed up in the words medullization, rarefaction, and decalcification. The medulla of the bone in craniotabes is affected differently according to the period of development that the bone has already attained when the rachitic process begins. In the beginning the medulla is very red and vascular. This appearance is most pronounced in the parts of the bone that are least thinned. At a later stage the medulla is replaced more and more by fibrous tissue. The rarefied bone shows on histological examination the remains of the bony canals surrounded by osteoid tissue, with a vascular and fibrous medulla, fusiform cells, blood cells, and a few medullary cells.

The actual causation of the softened areas in the cranial bones has been variously explained. The pressure of the child's head upon the pillow has been cited as a possible cause. But this explanation, while it may account for a diffuse depression and possibly a slight thinning of the posterior part of the cranium chiefly on the right side, does not account for the discrete and multiple areas of softening that are characteristic of true craniotabes. Furthermore, decubitus cannot be the cause of the softened areas in the anterior part of the calvarium which are observed in the congenital type of craniotabes. Some of the early writers advanced the theory that the depressions in the cranial bones are caused by the rhythmic expansion of the brain synchronous with the propulsion of blood through the cerebral arteries. Marfan and Renault formulated a plausible hypothesis based upon mechanical factors. They suggested that in true craniotabes the cranial bone, which has already been softened as the result of the rachitic changes, is subjected to pressure from the inside by the brain in the process of the latter's development. This hypothesis accords with the observation that the depressions on the inner surface of the cranial vault correspond exactly with the convolutions of the surface of the brain. Another mechanical factor is brought into play. The recumbent position of the child determines the chief direction in which the developing brain exerts its pressure upon its bony envelope, namely, in the posterior portion of the latter. On the other hand, in the congenital type of craniotabes that begins during intrauterine life, the usually inverted position of the fetus causes the pressure of the expanding brain to be exerted more upon the anterior portion of the calvarium. This accords with the fact that in the congenital type of craniotabes the softened areas are more apt to be in the anterior portion of the cranium.

Symptomatology and Diagnosis.—The evidence of the existence of craniotabes has been fully discussed in the previous paragraphs. It is important to differentiate between true craniotabes and the spurious types. It may be difficult to decide whether or not a syphilitic factor is present. A positive Wassermann reaction or the presence of definite clinical manifestations of inherited syphilis may, in the absence of rachitic symptoms, point to syphilis as the chief etiological factor in a case of craniotabes. The therapeutic test may quickly enable one to clear up any doubt on this point. In examining any infant, no matter how healthy it may seem, one should not fail to employ pressure upon different parts of the cranial vault with the view of detecting any softened spots. These may be the first and even the only evidence of rickets. When there are other cranial manifestations of this disease such as the presence of frontal and parietal bosses which give rise to the natiform type of cranium, one may at the same time detect areas of craniotabes. There may thus coexist in the same cranium areas of overgrowth and areas of absorption of bone. Cases in which hydrocephalus is present may offer a certain degree of difficulty in the diagnosis. Hydrocephalus, through the pressure exerted upon the cranial vault by the fluid within and surrounding the brain, may be a cause of craniotabes. This, on the other hand, may be accompanied by a slight hydrocephalus as a secondary manifestation. Thin cranial bones in premature or delicate infants may simulate true craniotabes. H. Neumann and E. Oberwarth point out that in premature infants the cranial bones, widely separated from one another at the sutures, have sharply defined edges, quite unlike the softened and indistinct edges of these bones in craniotabes. Actual defects of bone of congenital, traumatic, or operative origin should offer no difficulty in the diagnosis. It should be borne in mind also that erosion of the cranial bones may result from the pressure of intracranial tumors.

Jacobi has described a series of symptoms which he believed to be consecutive to craniotabes. These symptoms are profuse perspiration of the back of the head, falling out of the hair in this region, and restlessness and other nervous manifestations. The

dilatation of the veins of the scalp indicates that there is an increased intracranial pressure probably from a meningeal effusion. The above symptoms are attributed to the hyperemia of the meninges accompanying the increased vascularity of the bony vault of the cranium. Jacobi also attributed laryngismus stridulus, which is so closely associated with craniotabes, to the same cerebral irritation. Recent investigations have shown that the convulsive manifestations of rickets, including laryngismus stridulus, are the result of a generally increased irritability of the entire nervous system. It is therefore improbable that craniotabes either directly or indirectly produces nervous symptoms. Indeed, firm pressure upon the softened spots of the cranium does not elicit any phenomena arising from irritation of the cerebral cortex.

Prognosis and Treatment.—None of the manifestations of rickets responds so quickly to appropriate treatment as does craniotabes. The administration of phosphorus and cod-liver oil and the institution of the necessary hygienic and dietetic measures that should be adopted in a case of rickets, are followed by a speedy deposition of bone in the softened areas of the cranium. If these are of small size they require no special protection; but if extrusive they should be protected by means of a special cap provided with circular pads of gauze or cotton so arranged as to surround the softened patches of bone. In pronounced cases of craniotabes the infant's head should rest during sleep on a small inflated ring pillow, and the position of the head should be changed from time to time in order to prevent deformation of the cranium.

Alexander Spingarn.

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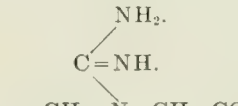
**Craw-craw.**—This term (written also kra-kra) is applied somewhat loosely to infectious papulo-pustular dermatitis, as found in various parts of Africa, and in Asia. It may be set up by infection of a mosquito bite or any other small wound, and spread by scratching and by the soiling of clothing with discharges from the primary focus. In the same way it may be developed as a sequel of scabies. The condition has been extensively observed in West Africa by Dr. John O'Neil, who found filarial embryos in the papules in many of his cases. But, as pointed out by Manson, these cases were seen in a region in which *Filaria perstans* occurs in every second individual, and in which other forms of filariasis are also common, and O'Neil's observation does not therefore afford any sufficient evidence that the dermatitis called craw-craw has any special relation to filariasis. Creighton Wellman, late medical officer in Angola, West Africa, says, "All the cases of the so-called tropical disease known as craw-craw which fell under my notice in West Africa were found to be scabies, some of the cases, however, being almost incredibly severe and neglected."

The condition to which the term craw-craw is applied requires vigorous surgical cleansing followed by the local application of antiseptics to the affected areas of skin. If an original scabies infection coexists, the inefficiency of many of the antiseptics as insecticides should be remembered, and carbolic acid or some form of ointment should enter into the treatment. Infected clothing should be sterilized or destroyed.

J. F. Leys.

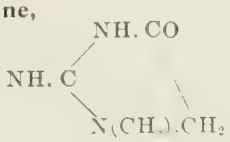
**Creatine,** Methyl guanidine acetic acid,



is one of the characteristic constituents of muscle tissue. It occurs in variable amounts from one to five per mille in different species; the largest quantity is found in birds. It may also be found in the brain, blood, transudates, amniotic fluid, and under certain conditions in the urine. It is normally present in the urine of young children. During inanition in the adult creatine appears in the urine in significant quantities and may be made to disappear by the ingestion of carbohydrates. It may also be excreted in the urine in acute fevers, and in various pathological states where there is a loss of large amounts of muscle proteins, or where the store of carbohydrate has been markedly depleted. Large outputs of creatine have been found in the urine of women during the first week postpartum when resolution of the uterus is taking place. Hepatic diseases and muscular dystrophies also lead to the appearance of creatine in the urine. Creatine is a strong base which on boiling with baryta water decomposes, yielding among other products urea and sarcosine. Creatine may be prepared synthetically from cyanamide and sarcosine (methyl glycocoll). Upon boiling creatine with hydrochloric acid for a sufficiently long time it may be converted quantitatively to creatinine, its anhydride. See also *Metabolism.*

Frank P. Underhill.

**Creatinine,**



is regarded as the anhydride of creatine, found in the muscles. It is a constant constituent of urine occurring there to the extent of one gram per day on the average. With a meat-free diet the creatinine elimination is variable for different individuals but is constant

for the same person. Creatine and creatinine are related in the metabolism of the body in some as yet undefined manner. In starvation creatine appears in the urine with a simultaneous decrease in the creatinine elimination. Creatinine acts as a reducing agent, reducing mercury and copper oxides. Because of this fact some of the tests for sugar in the urine are vitiated because of the presence of creatinine. See also *Metabolism.* FRANK P. UNDERHILL.

**Credé, Karl Siegmund Franz.**—Born in Berlin, Prussia, December 23, 1819. He received the degree of Doctor of Medicine from the University of Berlin in 1842. In 1850, after serving for five years as an assistant in the Obstetric Clinic under Professor Busch, he was made a Privatdozent in this department. In 1852 he became the Director of the Berlin School for Midwifery Nurses, and at the same time he was appointed Chief Surgeon of the Gynecological Division of the Charité Hospital. In 1856 he was called to Leipzig to fill the regular Chair of Obstetrics and to serve as Director of the Lying-in Establishment and School for Midwifery Nurses. In 1860

FIG. 1619.—Karl S. F. Credé.

the title of "Hofrat" was conferred upon him, and ten years later, in 1870, he received that of "Geheimer Medizinalrat." His death occurred on March 14, 1892.

Karl Credé ranks among the most distinguished obstetricians of our time. He will be remembered, however, chiefly because of two novel procedures which he introduced into the practice of midwifery, viz., that of "expressing the placenta," an account of which he published in 1860, and the prophylactic instillation into the conjunctiva of a silver nitrate solution for the purpose of preventing blennorrhea neonatorum. The latter practice has been universally adopted. Credé was specially gifted as a teacher, and his ability as an organizer was also a marked characteristic. Among his published writings the following deserve special mention: "Klinische Vorträge über Geburtshilfe," two volumes, 1853–1854; 'De optima in partu naturali placentam amovendi ratione," 1860; and "Die Verhütung der Augenentzündung der Neugeborenen," 1884. (Pagel.)

A. H. B.

**Cremation.**—See *Dead Bodies, Disposal of.*

**Crenothrix.**—A genus of bacteria of the family *Chlamydobacteriaceæ,* occurring in the form of cylindrical cells, twice as long as thick, united to form unbranched threads. The reproductive cells are of two sorts—microzonidia formed from the vegetating daughter cells, and macrozonidia formed from the terminal cells of the filaments. The cells divide first in one plane only, but later in three planes.

T. L. S.

**Creolin** is the trade name of a coal-tar product, of which cresols are the active ingredient. It is a dark brown syrupy liquid which, when diluted with water, forms an opaque milky emulsion. It has an odor like that of creosote. Creolin is a useful antiseptic and disinfectant, and is used to some extent as a substitute for carbolic acid. As ordinarily used it is less toxic than carbolic acid, and is also much less irritating to the hands of the physician and the tissues of the patient. For ordinary use a two-per-cent. solution is employed; this is well adapted for the hands, body, instruments, vaginal douche, moistening of surgical dressings, and general use in obstetrics. For this latter branch of medicine creolin is particularly adapted, as in addition to its antiseptic properties it is an admirable lubricant. A drawback is that it is opaque, and therefore instruments, etc., placed in a tray of creolin solution are not visible; at the same time the instruments are rendered slippery and so made hard to hold. For irrigation of the urethra or bladder, it is well to begin with a 0.5 per cent. solution, and gradually to increase this up to one or even two per cent. as tolerance is acquired. A similar weak solution has also been employed as a nasal douche in rhinitis with crust formation, and as an injection in cases of dysentery and colitis. R. J. E. SCOTT.

**Creosote.**—The title *creosote* belongs to a product of distillation of wood-tar, and much confusion has arisen from its application also to certain products of distillation of coal-tar, as in the title *coal-tar creosote.* This confusion, furthermore, has been worse confounded by the too frequent commercial trick of selling the coal-tar product in substitution for the wood-tar *creosote* proper. True creosote is recognized by the United States Pharmacopœia under the title *Creosotum,* and is defined to be "a mixture of phenols and phenol derivatives, chiefly guaiacol and creosol, obtained during the distillation of wood-tar, preferably of that derived from the beech."

Creosote is "an almost colorless, yellowish (not pinkish), highly refractive, oily liquid, having a penetrating, smoky odor, and a burning, caustic taste; it should not become brown in color on exposure to light. Specific gravity not below 1.072 at 25° C. (77° F.). Its solution in about 140 parts of water at 25° C. (77° F.) is not perfectly clear. With 120 parts of hot water it forms a clear liquid which on cooling becomes turbid from the separation of minute oily drops. . . . Soluble, in all proportions, in absolute alcohol, ether, chloroform, carbon disulphide, acetic acid, and fixed and volatile oils." (U. S. P.) A notable point of difference between creosote and carbolic acid is that creosote does not coagulate albumin or collodion, while carbolic acid does.

Creosote is closely related, chemically, to carbolic acid, and resembles that body in physiological properties. Creosote, however, while equalling carbolic acid in antiseptic power, is distinctly less poisonous to the animal economy. Because of this circumstance creosote has been used as an internal remedy in such diseases as pulmonary tuberculosis, in the hope of arresting the morbid process through a poisoning, within the body of the patient, of the tubercle bacillus. But whatever good may result from the treatment, it is quite certain that, as creosote is used internally, it does not affect the vital endowments of the tubercle bacillus.

Creosote tends to allay reflex nausea and vomiting, and to benefit pulmonary catarrhs, in the stage of active secretion.

For ordinary purposes creosote is prescribed in doses of three minims (0.2), to be taken preferably in capsule, and upon a full stomach. Considerable quantities, however, may be borne safely, and so much as several hundred drops has been given daily, and for

months, in the treatment of phthisis. But such dosage must be reached gradually, and care should be taken that the sample is pure and derived from the beech. Creosote is also inhaled in cases of fetid bronchitis, phthisis and for allaying the troublesome cough sometimes found in laryngitis. For this purpose, ten minims of creosote may be added to ten ounces of boiling water, or a mixture may be made of equal parts of creosote and spirit of chloroform, and used in a respirator. Injections of creosote have also been used in cases of phthisis, but the process is painful, special apparatus is required, and the method is generally unsatisfactory.

The United States Pharmacopœia makes official *Aqua Creosoti*, Creosote Water, a simple one-per-cent. solution of creosote in distilled water. Dose, two fluidrams (8.0).

*Differences between Carbolic Acid and Creosote.*—(1) Creosote is insoluble (or nearly so) in glycerin; carbolic acid is soluble in glycerin. (2) With collodion creosote mixes freely and does not coagulate; carbolic acid coagulates and becomes gelatinous. (3) With alcohol and ferric chloride creosote gives a green color; carbolic acid gives a brown or dark yellow. (4) If a chip of pine wood be placed in a distillate containing carbolic acid, and on removal be moistened with hydrochloric acid, it will get a blue color in about half an hour; with creosote there is no change of color.

Toxicology.—Poisoning by creosote has never become either popular or fashionable. The homicide and suicide have sought other means to attain their ends, and even "accident" and "negligence" have given creosote a wide berth. This prejudice against creosote exists on both sides of the Atlantic. Thus, in a table of about 1,500 deaths by poisoning occurring in the city of New York during the period 1841 to 1892, there are only two deaths from creosote, and both of them accidental (Witthaus and Becker's "Medical Jurisprudence, Forensic Medicine, and Toxicology"). And in England and Wales for a period of ten years (1883 to 1892) of 6,616 deaths from poison, only one was due to creosote, and this, too, was attributed to accident or negligence (Blyth, "Poisons"). Nor is it the general public and the criminals alone who thus ignore creosote; it is equally neglected by text-book writers. It is true that stray cases of poisoning by creosote are found in medical literature, but the text-books on poisoning and medical jurisprudence, as a rule, either omit the subject altogether or refer the reader to carbolic acid. The reason for this latter course is probably that creosote being a complex body, and its constituents varying so much and formerly containing an uncertain but fairly large quantity of phenol, it was difficult to pronounce on death caused by creosote.

*Lethal Dose.*—The smallest quantity which has been reported as causing death is three to six drops; on the other hand, in Wood's case, the patient took 600 drops and recovered without treatment. These are probably the extremes. Tolerance for creosote can be acquired; White says that 300 minims a day may be given for a considerable time with benefit. Graham reports the case of a patient taking 340 minims every day, and suffering no ill effects therefrom.

*Symptoms.*—The symptoms, which may come on very rapidly, are nausea; vomiting, which is not regular and may be slight; severe abdominal pain, gastric disturbance, and purging; malaise; vertigo; headache; prostration; anxious expression; pinched face; subnormal temperature; skin cold and clammy, and covered with perspiration; depressed heart action, with pulse weak and thready or imperceptible; stertorous breathing; dyspnea; dimness of vision, and contraction of pupils: tendency to stupor; abolition of reflexes: possible cyanosis. The urine may or may not have the odor of phenol; it is rarely albuminous, and pigmentation, if present, is probably due to oxidation products of the phenol group. A. H. Smith says the occasional smoky urine is the result of a harmless chemical reaction, and not of hemolysis. If there are local symptoms they begin to manifest themselves at once; there may be pain in the region of the kidneys. According to Sajous, "death occurs from failure of respiration, and the heart is arrested in diastole."

*Postmortem Appearances.*—These appearances are those of corrosion and vary according to the degree of concentration. The odor of creosote may or may not be present.

*Treatment.*—In cases of *gradual* poisoning withdraw the drug; if the urine becomes discolored or digestion disturbed reduce the dose. In *acute* cases wash out the stomach, give doses of Epsom or Glauber's salt, and warm demulcent drinks; saccharate of lime (fresh quicklime 15 parts, sugar 25 parts, water 1,000 parts) is also beneficial; apply heat externally, and counter-irritation over the abdomen; give respiratory and cardiac stimulants, strychnine and digitalis, and if necessary a hypodermic of ether. R. J. E. Scott.

**Cresalol.**—$C_6H_4.OH.CO.C_6H_4CH_3$ is cresyl salicylate and stands in the same relation to cresylic acid that salol does to carbolic acid. Para-cresalol is generally used, though ortho- and meta-cresalol can also be prepared. It is chiefly used as an intestinal antiseptic; and, like salol, it is decomposed in the intestinal tract. The decomposition products are cresylic acid and salicylic acid. It has also been used in rheumatic conditions. Cresalol is a white, crystalline powder, insoluble in water, and but slightly soluble in alcohol. The dose is gr. v.–xv. (0.3–1.0), in capsule. R. J. E. Scott.

**Cresamine.**—A mixture of twenty-five per cent. each of tricresol and ethylene diamin. A two per cent. solution of this is used as an antiseptic.
R. J. E. Scott.

**Cresol** is a mixture of ortho-, meta-, and para-cresols, three isomeric bodies obtained from coal tar. The general formula for cresol is $C_6H_4.CH_3.OH$. It is official in the United States Pharmacopœia as *Cresol*. It is "a colorless or straw-colored refractive liquid, having a phenol-like odor, and turning yellowish-brown on prolonged exposure to light. Cresol is soluble in sixty parts of water at 25° C. (77° F.); miscible in all proportions with petroleum benzin, benzene, alcohol, ether, and glycerin; miscible with alkali hydroxide solutions." (U. S. P.)

Cresol is a useful germicide, and is said to be more toxic to bacteria than phenol is, and less toxic to the higher animals. The toxicity of cresol depends upon the relative proportions of the ortho-, meta-, and para-constituents; and, unfortunately, the United States Pharmacopœia does not definitely state the proportion in which these three cresols should be present. Cresol is used in much the same way as phenol; the dose is one minim (0.06). For surgical work a one-per-cent. solution is used, cresol being about three times as germicidal as phenol.

The *Liquor Cresolis Compositus* (Compound Solution of Cresol) of the U. S. P. is a solution of fifty per cent. strength. From this various solutions may be prepared for disinfecting excreta; and a one-half-per-cent. solution may be made for use in cystitis. This Liquor Cresolis Compositus is practically identical with lysol, and may be similarly used in obstetric practice. R. J. E. Scott.

**Cresotic Acid, Cresotinic Acid.**—This is a homologue of salicylic acid to which it is allied in physical, chemical, and physiological properties. Its

formula is $C_6H_3.OH.CH_3.COOH$. There are three isomeric acids, the ortho-, meta-, and paracresotic acids. They are always present in salicylic acid of commerce. The ill effects that often follow the employment of salicylic acid have been attributed to the presence of ortho- and paracresotic acids.

The only preparation of this acid employed for therapeutic purposes is the paracresotate of sodium. It possesses antipyretic and antirheumatic properties similar to those possessed by sodium salicylate, but in a lesser degree. The dose is from five to twenty grains three or four times a day; it is free from toxic action, and may be administered more freely if necessary.

EDWARD CURTIS.
R. J. E. SCOTT.

**Creta Præparata.**—See *Calcium*.

**Cretinism.**—This is a broad general term applied to a combination of physical and mental changes which, in the young, result from loss or diminution of the thyroid functions. Such a loss may occur sporadically (*Sporadic cretinism*) from causes to be enumerated, where the picture is analogous to that seen in the adult from removal of the thyroid, cachexia thyreopriva adultorum; or it may occur as a localized or *endemic* degeneration affecting the thyroids of a large number of individuals, causing a hypothyreosis which may show a number of tendencies. The chief of these are *goiter*, *goitrous heart*, and *endemic cretinism*.

These four fairly well separated conditions may be discussed to advantage under the head of cretinism. In the first place to call cretinism a type of idiocy is nonsense. There are numerous very intelligent cretins. Cretinism, as here used, is solely a series of different conditions due to a lack of development of one or more elements in the body and due to defect or loss of the thyroid hormones.

The historical chapters on cretinism are full of interest. The disorders were known in early days. Pliny has left indubitable evidence of their presence in early Roman times. Vogt in his admirable monograph in the Lewandowsky Handbuch der Neurologie tells of Marco Polo's descriptions of certain types he had seen in his Asiatic travels. During the past two centuries the disorders here included under the term have been observed through the world. In certain lands, especially certain mountainous districts of Switzerland, Northern Italy, etc., the disease is very widely distributed—endemic cretinism—while in other regions it occurs rarely—sporadic cases. In the United States it is not frequent. It has been observed in California, in Vermont, and the writer has seen such patients in New York State (Adirondacks). In certain regions it has been a veritable plague. Thus in Switzerland, between the years 1875–1884 seven per cent. of the recruits in the army showed some form of cretinoid degeneration. In ten years 2,500 men were lost to the Swiss army from this cause alone. Certain valleys, especially those of Berne and Wallis, are thickly populated with individuals showing cretinoid degeneration. In the school years 1899–1904, of 336,000 children fit for school 15,000 had one or another type of cretinism. Similar conditions existed in Styria, in Austria, and in certain Italian provinces. F. Bircher[1] has contributed an important study to the distribution of cretinoid degeneration.

So far as the etiology is concerned, it seems certain that the conditions are due to a defect of the thyroid substance—diminution or loss of the thyroid hormones. There are certain limitations which must be discussed in their respective paragraphs.

SPORADIC CRETINISM.—Infantile Myxedema. The clinical picture in an extreme case—*i.e.* fully developed, in contrast to the many irregular or incomplete forms—is that of a normally born child who, about the end of the first or the beginning of the second year begins to show the characteristic changes in development. The little patients fall behind in their normal bony development. This is due to a defect in the development of the long bones. The epiphyses fail to lay down bone even after twenty to thirty-five years and in twenty-year-old cretins the anterior fontanelle may still remain open. There is a proportionate loss in bone substance throughout; thus a characteristic dwarfism results save perhaps in the development of the skull which becomes larger in proportion to the rest of the body. The sphenoid, however, fails to develop and therefore gives the peculiar characteristic nose to the cretin. The bony defect is in the nature of a sclerosis and the bone is unusually hard, which is the reverse of that seen in rachitis.

Dental deficiencies go hand in hand with the bony defect. In severe athyroid cretins the teeth do not develop for a number of years, and the first or milk teeth may persist far beyond the normal period. The bony defects show in a high palate arch, with large adenoids and tonsils, and a chronic hypertrophic rhinitis causes the child to snore and sniffle, often with copious excretions from the nose.

FIG. 1620.—Sporadic Cretinism in a Person aged 28 Years; height 34½ inches. (George R. Murray.)

A fairly constant finding is that of umbilical hernia. The abdomen is usually puffy, the navel sunken. The skin is myxedematous in the young, but becomes atrophic in later years, the supraclavicular and facial swelling remaining for many years.

The facial habitus is characteristic. The hair line begins low, the nose is sunken, the zygomatic arches prominent, the eyelids swollen, the face puffy, the tongue enlarged and often protruding between the swollen lips, in the mild cases giving one the impres-

sion of a child whose whole countenance is puffed up with crying.

There is usually an enlargement of the liver. Respiration is unusually slow in the severe athyreoses. The genital organs show marked changes. The labia are small, the external not covering the internal ones. The uterus and ovaries are usually small, and the mammary glands are atrophic or hypoplastic. The penis is apt to be small, the testicles undescended, and small. Genita hair and that in the arm pits is absent or scanty. In boys the puberal changes in the voice are lacking.

Blood changes are present. The hemoglobin is reduced and is out of proportion to the erythrocytes.

Fig. 1621.—A Cretin, about Thirty-three years old, formerly in the Philadelphia Hospital. The man beside him was his voluntary caretaker for many years.

The leucocytes are increased, the polymorphic neutrophiles being markedly diminished and the lymphocytes correspondingly increased. Large numbers of granular cells are observed. These changes appear as a result of defective thyroid substance.

The metabolism of calcium is markedly diminished ($\frac{1}{3}$ of its normal amount in the studies made by Haugardy and Langstein[2]) and the required calories are far below that of the normal child's need. The assimilation of carbohydrates seems high, and adrenalin injections, without increased sugar intake, do not result in a glycosuria. There is a definite hypothermia. In many cretins there is a widening of the sella turcica. Hypoplasia of the thymus is also not infrequent.

Nervous system defects are present with the others and apparently conditioned by the endocrinous gland insufficiencies. These show at vital levels in the deficiencies of the sensory and motor nerves, and at psychical levels in various grades of stupidity, mental weakness (moron), imbecility, or even idiocy—these words being used according to the arbitrary scaling of the Binet-Simon tests.

Thus smell is at times defective. The eyesight is poor, hearing is frequently disturbed and with it speech, so that many patients are deaf and dumb. The vestibular function is frequently involved, so that these patients balance badly, often showing unsteady gait, wobbling of the head, and nystagmus.

Some sporadic cretins may show little disease of the nervous system.

Cretinoid Degeneration.—Mention has been made of the widespread character of this type of degeneration related to defective or absent thyroid secretions. The statistical study of the conditions, particularly in Switzerland, in France and in Italy (Bircher,[1]) has shown that goiter, goitrous heart, endemic cretinism, endemic deaf and dumbness, and endemic feeblemindedness are closely allied. The cretins are almost all goitrous, or nearly always have goitrous parents. Exophthalmic goiter (hyperfunction) is rare with goiter, but very frequent with goitrous heart conditions.

The causes of the hypothyroidism are not definitely settled but there seems to be a constant relation between it and certain factors in certain waters, so that goitrous springs are known. Just what the noxious element may be is still conjectural but it apparently is related to mineral constituents found in certain geological formations, notably in the Trias and Tertiary. The disease is absent in regions fed from waters of crystalline formation. Through Bircher's suggestion of supplying a goitrous region in Rupperwill from Jura water supplies, in an adjacent valley, the disease disappeared. Similar results followed in the town of Asp. Animals may be made goitrous from drinking water from certain springs. They also develop goitrous hearts, and are delayed in their development. The thyroid shows degenerative changes. The agent passes through a Berkefeld filter, but is modified and made non-active by being heated to 70° C. It does not dialyse and is not thought to be an organized plant or animal substance but is of a colloidal nature. An hypothesis which had the authority of Bircher behind it was that the disease was of an infectious nature.

*Goiter.*—Here Falta[3] describes those enlarged hyperplastic, non-inflammatory thyroid formations, with degenerative changes in the struma. The hyperplasia invades the parenchyma and the vessels. Notwithstanding histological hyperplasia there is physiological diminution in function. Functionating parenchyma, however, does not exist. Histologically one finds parenchymatous, vascular, or fibrous hyperplasias, with circumscribed or diffuse goiters. A relationship between goiter and uterine myomata exists, and with a diminution of one there is a decrease of the other at the menopause.

*Goiter Heart.*—See Exophthalmic goiter.

Endemic Cretinism.—Here there is a richer and much more variable picture than obtains for sporadic cretinism. Whereas a typical habitus is described, there are many anomalies and variations. The head is usually broad (but may be small and flat, instead of large and broad), at times very large. The nose is usually wide spreading and flat, the eyes wide apart. The neck is short and thick, the features swollen, the facial expression, especially of the prognathism, is one of moroseness or stolidity. The bones are shortened, various anomalies as scoliosis, ankyloses, etc., being present. Great variation in dwarfism is observed. Certain cretins are under three feet six inches, but full cretins have been observed of seven feet in height. As a rule they die young, but Kocher reports cretins seventy and even 100 years of age.

The general coordination of these patients is poor. They are usually short, clumsy, unelastic with badly

developed musculature. The skin is loose, lax, anemic, marked with folds and wrinkles, giving a peculiar appearance of old age. The lips are swollen, the tongue is enlarged and not infrequently protruding. The breasts are flat or badly developed, the abdomen flat or pendulous. Short stumpy fingers and toes give an ugly appearance to the extremities and contribute to clumsiness. The entire activity is apt to be heavy and awkward, although a few athletes and acrobats may be found among cretins.

The changes in the bones have been mentioned in the paragraphs on sporadic cretinism. Here, however, the variations are more marked and Weygandt's study of Virchow's material shows that many bony anomalies exist among cretins not mentioned in Virchow's classic which has remained a standard for writers for many years.

The skin has a peculiar cachexia. It is swollen and flabby, whitish or yellowish, folded and soggy. The general appearance of old age is striking. The hair and nails are badly developed, both breaking easily. Thick, underlying fatty masses are unevenly distributed, usually in the neck, back, upper chest regions, occasionally over the hands. Variable states of tension occur in these fatty masses; at times they are hard, again like empty sacks. The mucous membranes are also pale and gray, often folded but look different from a typical anemia.

The sexual organ changes have been touched upon in the description of sporadic cretinism. They are characteristically infantile. Menstruation is scanty, wanting, or develops very late. Fecundation may take place, but the results are either miscarriages, dead children, various monsters, etc. The secondary sexual characters are all delayed in their development.

The majority (sixty-three per cent., Ewald) of cretins show a swollen thyroid, but it is not an overfunctioning one, nor do they all show athyreosis, or hypothyreosis. Schonemann has reported the findings of strumous changes in the glandular portion of the hypophysis. In 112 autopsies on endemic cretins he found a normal hypophysis in only twenty-seven instances. These individuals had no goiter. He states that in individuals with struma of the thyroid almost invariably there was an increase in the size of the hypophysis, consisting chiefly of increase in the connective tissue, also the chromaffin cells, struma of the vessels, hyaline degeneration, and swelling of the cell strands, and finally goiters with colloid formation. It is highly probable, therefore, that the goiter poison works deleteriously upon the hypophysis (Falta[3]). The parathyroids show no changes.

Most of the internal organs show reduction in activity. Digestion is usually slow, constipation is marked. The metabolism is modified as already indicated. The urinary secretions are apt to be diminished, and of high specific gravity.

Mentally cretins show marked variability. A few are practically normal, but most show a characteristic combination of mental traits, in contrast with many other mental defective states. The feeble-mindedness is accompanied by great slowness of all reactions, marked retardation of motion, apathy, and indolence. This indolence is a marked feature. Many cretins will lie in the sun all day long, and in the hospital or other institutions will lie around and do nothing for weeks or months. In the milder grades there is often great shyness which makes them unapproachable and serves to make them appear more feeble-minded than they really are. It is with the greatest difficulty that they can be trained to the simplest of performances. With many, in spite of the marked general stolidity of their average mood, they may show great excitement and emotional outbreaks.

They are very negligent, love to sit still, but many show much variability in this respect. As noted the great majority suffer from impairment of the chief sensory tracts. Hearing seems to suffer most. The defect in hearing is associated with speech defects. Taste and smell are also involved. They take little interest in their food or drink and therefore show little interest in hunger, which is marked. The sense of sight is frequently diminished. It is highly probable that the receptors and conduction paths are less involved than the perception areas in this diminution in sensory intake. The hearing seems to be affected primarily as to its receptor and conduction paths. Pain, touch and thermal sensibilities are all dulled. Motility is extremely retarded. The reflexes are active (fifty per cent.). The field of vision is reduced in many, although the fundus is usually normal (Hitschmann).

Aberrant and abortive types are to be expected. In the former one may find patients with striking development of one or more features, in the latter a very great shading off to almost normal states, *i.e.* endemic goiter with mild mental signs.

*Endemic Deafmutism.*—This combination is extremely frequent where endemic cretinism is present (twenty-nine per cent., Scholz). It may constitute one of the aberrant types just mentioned with striking development of single features, or it may be associated with all the grades of a complete cretin picture. According to the studies of Kocher, the loss of hearing is due to a bony defect which has destroyed the possibility of normal cochlear development. Bad hearing is reported at thirty-two per cent. among cretins in Scholz's investigations.

The changes found in the brain which may account for the feeble-mindedness have been variable. Meningeal inflammation and mild grades of hydrocephalus have been found by Scholz and Zingerle. The brain is often symmetrical, small, or single lobes are diminished in size. Often the brain's development is arrested at an infantile stage, the pallium or the ganglia being involved alone or together. The cerebellum is often imperfectly developed, which fact stands in correlation with the marked incoordination and possibly in relation with defective labyrinthine development.

The ear difficulties have been protean. Peripheral, conducting, and central mechanisms have been found at fault; at all events they all seem secondary to the developmental anomalies induced by the action of the poisonous substance on the thyroid. The speech defects usually go hand in hand with those of hearing, but this is not universal. The cortical developmental defect is sufficiently explanatory for most of the cases.

THERAPY.—Many contradictions may be found in the literature concerning the use of thyroid substance in cretinoid degeneration. This is to be expected since so many observers use their diagnostic terms so lightly. Age differences are not recorded—stage and intensity of the disease—and grades of defect are overlooked, and hence no uniform basis for comparisons has existed.

Among the best reported results are those of v. Wagner who obtained a diminution in the myxedematous swelling of the skin, rapid development of the genitals, diminution in size of the tongue, disappearance of the umbilical hernia, development of new hair, hastening of dentition, closure of the fontanelles, increase in bony development. The psyche was less hopefully modified, but there was a diminution in the apathy, and slight increase in intellectual capacity.

Early therapy is naturally the main feature. According to v. Wagner, small doses of iodine in addition seemed to stimulate the thyroid activities still further. Magnus Levy, v. Eysselt, and others also report excellent results, complete cure resulting in some patients still in their teens.

A widespread State experiment carried out by v.

Kutscheras in Styria treated 1011 cretins. A large number were neglected by the parents, *i.e.* treatment was not kept up. In 2.4 per cent. the thyroid tablets could not be well borne. All idiots and severe grades of deafness and dumbness were left alone. Of 440 of the cases 10.2 per cent. showed slight increase in bony development, 4 per cent. showed definite change, 85 per cent. showed an increase well above the average. The increase in bony growth was marked with the younger individuals, but also persisted into the third decade.

A careful revision of 677 cases showed 42.8 per cent. marked improvement, 48 per cent. some definite improvement, 8.6 per cent. no improvement.

Scholz's experiences with 100 cretins in an institution were disappointing. He used as many as eight tablets a day. v. Wagner claims the doses were too extreme, hence the bad results. Emaciation, weakness, loss of appetite, vomiting and diarrhea, and other symptoms of hyperthyroidism developed. v. Wagner recommends the use of only one-half or one tablet (thyroidinum siccum, Merck = gram 0.1); 0.4 gram corresponds to the activity of an entire gland. (Burroughs Wellcome Co., 0.1-0.3 gram = gr. jss-v.)

Iodothyrene has also been utilized. One gram contains three milligrammes of active substance representing the iodine content of one gram of fresh sheep's thyroid. It would seem that the iodine content is not the only factor in the activity of the thyroid substance and it is not as yet definitely demonstrated what the combination is that is effective. The result of the use of implanting of glandular substance would be the ideal therapy, and experiments directed to this end have been attempted since 1889 when Bircher was one of the first to attempt it. The gland has been implanted in different portions of the body—the neck, under the breast, in the spleen, even in the bony substance. As a rule, however, the implantation has not been as successful as was hoped, the gland itself undergoing retrograde changes. Furthermore it would appear from the studies by Enderlen and Borst that thyroids from other animals possibly are not the best things to use as the biochemical composition of the human and animal types varies so widely as to render degeneration of the implanted gland likely. Implantation of human glands has not been successfully brought about as yet, but with the newer work on organic transplantation as inaugurated through the researches of Carrel it would seem that this technical difficulty might be overcome in the very near future.

One is compelled, therefore, to resort in most cases to the dried or liquid preparations of the thyroid itself or to such biochemical products as laboratory research has provided through the utilization of the glandular substance itself or that portion of it which presents its chief hormone activity.

The general results of thyroid medication in typical cases is fairly constant. Especially is it of value in the aberrant and minor forms of the disease of which one of the most chronic of symptoms is the persistent anemia. This may be in part overcome by the simultaneous use of small doses of arsenic, which have been recommended by a number of experimenters. Alcohol and morphine work disadvantageously, and should be carefully avoided. The use of small doses of sodium bicarbonate and bismuth work advantageously in diarrheal states.

Thyroid medication for the sporadic cases varies somewhat from its use in the endemic cases. In the sporadic cases of the light or mild type the action is quite similar to that seen in the endemic ones, but as a rule, sporadic cases by reason of their longer involvement and the less rapid development of the symptoms, the more hidden or obscure nature of the same, with their great mixture of syndromes, make such cases less responsive to the therapy. Nevertheless, many of them respond very kindly to it, the same dosage being utilized. SMITH ELY JELLIFFE.

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**Criminals and Defectives, Asexualization of.**—The subject of the prevention of procreation in the criminal and defective classes first claimed attention when the State of Indiana, by a legislative act dated February 10, 1907, gave authority to superintendents or boards of managers of institutions where confirmed criminals, idiots, imbeciles, and rapists were confined, to appoint a committee of experts, consisting of two physicians, to examine into the mental conditions of such inmates. If in the judgment of this committee, which consisted in addition to the regular physician of the institution of two skilled surgeons of recognized ability, procreation was deemed inadvisable in any of the inmates recommended by the institution physician and board of managers, then it became lawful for the surgeons to perform such operation for the prevention of procreation as was decided to be "safest and most effective." On December 13, 1907, Dr. William T. Belfield read, at a joint meeting of the Physicians' Club and the Law Club of Chicago, a paper in which he advised vasectomy—section of the vas deferens—in order to produce sterilization in confirmed criminals, idiots, imbeciles, and rapists, and stated that in the Indiana State Prison at Jeffersonville over 300 convicts under the age of thirty years had been sterilized by this operation, some by authority of the State, but over 200 of them at their own request. Attention is directed to this statement of Dr. Belfield as it places on record the fact that in the case of inmates of an institution of the State the provisions of the law authorizing inhibition of procreation has been enforced and the still more remarkable fact as stated, that over 200 convicts had submitted to the operation at their own request.

Since the enactment of the law of the State of Indiana, some twelve or more States have placed on their statute books laws inhibiting procreation in the confirmed criminal and defective subjects, varying, the one from the other, in several important points in the character of the operation which shall be performed, the conditions, physical, mental, and moral, which make the operation justifiable or necessary, and the constitution of the official committee upon which shall be placed the responsibility of determining the question of an operation. As to the character of the surgical procedure to be instituted, the law of the State of Connecticut provides that the operation of vasectomy or oophorectomy shall be performed. These operations are markedly different in character and in the results which follow; vasectomy in the male simply arresting the passage of the secretion of the testes to the seminal vesicles and discharging it upon the pampiniform vessels where it is claimed it will be absorbed, oophorectomy in the female, which involves the removal of ovaries, producing asexualization, absolutely. The text of the Act does not make it evident why this distinction in the character of the surgical procedure should have been made in the two sexes. The operation of vasectomy in the male does not obliterate the sexual instinct as does oophorectomy in the female.

The law of the State of California distinctly specifies that *asexualization* may be performed in the case of inmates of the State hospitals, and of homes for the care and training of feeble-minded children, and of

convicts in the State prisons. The provisions of the law are broad and given largely in detail in the text. Asexualization shall be performed when it is decided by the executive and medical superintendents that it will be conducive to the benefit of the physical, mental, or moral condition of any inmate of the State institutions. In the case of the convict it is required that he shall have been committed to a State prison at least two times for some sexual offense and at least three times for any other crime and shall have given evidence while an inmate of prison of the State that he is a moral and sexual pervert. Convicts under sentence for life may be asexualized who exhibit continued evidence of moral and sexual depravity—this right exists when they have been inmates of a State prison either in California or any other State or country more than one time. It will be observed that in the case of the defective subject the intent of the law relates to the physical, mental and moral betterment of the inmates which asexualization confers, rather than to inhibition of procreation which contributes through the agencies of hereditation to race betterment. Also the statement as to the number of commitments endured by the convict defines the status of the confirmed criminal.

As to the character of the operation which shall be performed the law of the State of Indiana specifies that such operation shall be performed as is decided by the committee appointed under the provisions of the law to be the "safest and most effective." This was a wise provision, to have left to the judgment and to the discretion of the committee the choice of the operation, since the cases in which operations are justifiable may vary much in character and the benefit to be derived might be nullified if the surgeon was restricted by the terms of the law to the employment of a specified operation.

The laws of the three States which we have examined give information as to the nature of the operation which may be performed in inhibiting procreation in the confirmed criminal and defective subject. In only one is the operation distinctly specified, that of Connecticut. In the California law asexualization is demanded by the terms of the law and this can only be accomplished either by ligature of the spermatic cord as advocated by the writer, or by castration. The operation of cord ligature was devised by the writer as a substitute for castration, as this latter operation while completely effective arouses opposition by reason of the mutilation which follows its employment. In the Indiana law the operation to be performed is left to the judgment and discretion of the surgeon, that "safest and most effective"—with the discretion thus given—castration may be performed, although, as cited above, the operation of vasectomy appears to have been the only operation performed. In the laws of other States with the provisions of which we are familiar, the term sterilization is generally used, without as a rule the specification of any particular operation. The condition of sterilization may be accomplished by vasectomy, cord ligature, or castration.

According to the views of the writer, as set forth in his book on the "Problem of Race Betterment," simple inhibition of procreation does not fulfill entirely the duty owed by the State to all classes of confirmed criminals and of defective subjects. In the confirmed criminal who is not, as described in the text of the California law, a "sexual pervert," prevention of procreation may fulfill the intent of the law as it will arrest absolutely the propagation of his kind and in this respect will prevent the transmission through the subtle agencies of heredity of the traits of character belonging to him. This power of transmission is well illustrated in the case of the notorious Jukes family, a family of criminals, whose history is graphically given by Mr. Richard L. Dugdale, the author of a book on the subject. The history of this family, stretching through seven generations, included as the aggregate some twelve hundred descendants, who had been burdens on the communities in which they lived as paupers, imbeciles, or criminals, and who had cost the communities during the seventy-five years of the life of the family the astounding sum of $1,308,000. The history of two other families of criminals presents a continuous record of life in poorhouses, houses of refuge, women's reformatories, prisons, and penitentiaries with unintermitted support by the communities in which they lived.

In one class of criminals, the rapists, simple sterilization as is accomplished by the operation of vasectomy which leaves in their possession the sexual power, does not fulfill the purposes intended by the law. The object of any surgical procedure in their cases should include not only the betterment of future generations, but the protection of the community in which they live by removing the inspiration to crime which takes its origin in uncontrolled sexual desire. This can alone be accomplished by asexualization as provided in the California law and through the operation of either cord ligature or castration.

One State only, of the three whose laws we have studied, Indiana, prescribes the class of subjects in which sexual potentiality should be abrogated. This class includes criminals, idiots, imbeciles, and rapists; to these should be added perverts, degenerates, epileptics, and the vicious insane. With the exception of perverts and degenerates, as a class, all of those mentioned are found in the public institutions of the State and as inmates and beneficiaries of the State are under the care and control legally of the State. Perverts and degenerates when unrestrained become members usually of the criminal classes and as such place themselves under the direct control of the state and may be treated as either members of the criminal class or defective subjects. In the home and in the walks of private life where the baneful influences of their traits of character are felt in most harmful manner they can be subjected to surgical procedures producing asexualization only through their own consent or by that of the parent or guardian. There can be no question as to the great necessity which exists for arresting the flow of degeneracy through the power they possess of perpetuating their kind. It behooves communities therefore to develop a state of public opinion as will give approval to such methods of treatment in their cases as have been indicated.

Epileptics are included in the class of defective subjects as those who should be legitimate subjects for the interference of the laws in inhibiting procreation; not the members of this class in whom the condition of disordered function is the result of traumatisms, which in many instances may be relieved by surgical procedures, but those who are found as inmates in the eleemosynary institutions, in the schools for instruction of the feeble-minded, and in the colonies of isolation. As a rule in these subjects, sexual perversions are present, which become an exciting cause in the progressive development of disordered conditions, and make their care sources of difficulties which tax the ingenuity of their caretakers to prevent sexual abuses and restrain the almost constant mental distortion which accompanies the disease. In these asexualization is the rational remedy, accomplishing certainly palliative, and in some instances curative results. The history of the past and of the present day records the fact that many of the great men of the world, statesmen, warriors, scholars, have been the subjects of epilepsy or epileptiform seizures, which have not in any marked degree taken from them the attributes of their greatness or minimized their mental power. This fact has been used by some who are hostile to the inhibition of the procreative power in defective subjects. The argument used in promoting this hostility is not only illogical, but irrelevant, as the conditions are widely separate. Moreover, the history of

the world shows that genius is sterile, if this fact may be used in the consideration of the subject.

The descriptive terms, idiot and imbecile, are used in defining certain defective subjects who, under the laws of the States authorizing surgical procedures in producing inhibition of procreation come under the provision of the laws. The definition of the word "idiot" is, "a born fool"—the imbecile is one who is "mentally weak." These terms are descriptively interchangeable; both can be correctly designated as the subjects of "Amentia—without mind"—belonging to the feeble-minded class, a large class in our communities among children coming in great extent from the alien races who, under the glaring evils of our political systems, enter in such hordes through the gates of illy-protected immigrant stations, their admission fostered by the greed of the powerful steamship companies and the grafting methods of the politicians of low and high degree. Recent statistics show that thirty per cent. of the feeble-minded children in the general population of the United States are the progeny of aliens or naturalized citizens. These are found in large numbers in our public schools and in our eleemosynary institutions where they become burdens on the people of the States. In the public schools of the city of New York a recent report made by a special committee states that the number of feeble-minded children in the city's public schools is about one per cent. of the school population, nearly 10,000.

The failures to obtain any far-reaching results by training, attempts at education, and discipline in our institutions for the training of feeble-minded children are clearly explained by the recent investigations into the histological and pathological conditions which are found to exist in the brains of the subjects of amentia. These investigations have shown departures from the normal structures in all parts of the brain, more especially in all parts which concern intellection—in the marked absence of nerve cells and in their structure—in these respects differing from conditions found to exist in the normal brain.

The size and weight of the brain attract attention, the latter being much below the normal weight—forty-nine and one-half ounces—varying in a number of cases from ten to twenty ounces. Microcephalic subjects exhibit remarkably small brains, the lowest in weight as recorded not exceeding about six ounces—in a girl of this type who lived to the age of twelve years the brain weight was seven ounces—her intelligence was limited to the recognition of her nurse, and to the execution of a few simple commands, being in all respects not much above that found in animals of a lower order.

A significant departure from the normal is noted in the proportion of size and weight of the cerebellum and cerebrum the former being large in proportion and sometimes uncovered by the occipital lobes of the cerebrum; the anterior lobes of the cerebrum, important centers of psychic power, are frequently relatively diminished in size. Tredgolds's studies show that not only is there "a numerical deficiency of nerve cells in the brains of the ament, as compared with those of the normal subject, but there is present an irregular arrangement and imperfect development of individual cells in direct proportion to the degree of mental deficiency during life"—also the presence of a "type of undeveloped nerve cells which it is stated have not been found in any human brain other than that of the ament." Similar cells, however, it has been affirmed have been described by Bevan Lewis in certain layers of the cerebral cortex of the ape. Wilmarth has found tracts of considerable size in the brains of the ament in which very few nerve cells were present, and Spiller in the comparison he has made of the brains of the feeble-minded and of normal individuals has found a decrease in the number of cells in the feeble-minded.

In the ament, therefore, there is not only a scarcity of cerebral nerve cells, but they may be endowed from the period of embryonic life with defective elements which deprive them of the power of resistance to the influences of diseases and toxins and of the changed conditions of life which accompany the adolescent period. The study of the histological and pathological conditions found in the brains of the ament make it not difficult to fix his status and to make it the duty of the State to inhibit the propagation of his kind. The cerebral conditions found in the ament may be due to the mysterious forces of hereditation, perverted conditions of embryonic life, grave pathological conditions resulting from dystocia, or the influence of toxins in early childhood, all conspiring to arrest cerebral development. Heredity according to Tredgold contributes the large percentage of eighty in the production of the defective classes.

The vicious insane present a class of subjects which in many instances may be greatly benefited by asexualization. In several institutions for the insane experience has shown this to be correct, asexualization seeming to act in these cases as it does in the lower order of animals, removing ungovernable dispositions which lead to uncontrolled acts of violence and contributing to a docile temperament and to behavior in all respects correct. When sexual abuses are present the benefit is very marked.

In the drafting of any law giving the State the right to institute surgical procedures in the criminal and defective subjects, beneficiaries in public institutions of a State, great care should be exercised in defining its provisions. The first important question to decide relates to the power of the State to take from the individual the right to perpetuate his kind. In the normal individual a physically, mentally, and morally sound subject, and those citizens of the State who are able "to perform their duties as members of society in the position of life to which they were born" this question does not admit of discussion. In such the right is inherent and cannot be taken away under the laws which govern any civilized community. When, on the other hand, the individual for some cause, congenital or acquired, is in his life possessed of such qualities, mental or moral, as make him hostile to the best interests of the community, and to future generations through the power of procreation, then it would seem to be just that the State in the exercise of its duty as protector of its citizens in their rights and privileges should have the authority to arrest through the inhibition of procreation in such individuals the perpetuation of their kind. Moreover, experience has proven that in many of these cases asexualization has contributed to mental and moral betterment and is valuable as a remedial agency, and should be employed as a remedy in such cases as the knowledge and judgment of the physician may deem justifiable.

The question of the invasion of the inalienable rights of an individual by depriving him of the power of procreation it seems to the writer is answered when the conditions physical, mental, or moral of, for instance, the imbecile—the subject of amentia, is taken into consideration. By reason of the arrested cerebral development in his case he, not through his own fault, but through the occurrences of conditions for which he is not responsible and over which he has no control, has lost the inalienable rights which belong to a normal individual, if indeed he ever possessed them, as a member of society able to perform his duties in the position of life to which he was born. He cannot enjoy those rights without danger to the community in which he lives, the members of which the duty rests upon the State to protect. Protection can alone be afforded through the provisions of the law enacted by the State and executed by those acting under its authority.

Of the defective classes there are certain members who may take their place in the community as a self-

supporting class after asexualization has been performed to inhibit procreation, thus relieving the State of the burden of their care and keep which is imposed under any system of segregation which may be devised.

Reference has been made to the character of the operation which the State shall authorize to be performed in inhibiting procreation in the criminal and defective classes. It would seem desirable, as has been stated, to leave it to the judgment of the committee appointed under the law to select that which is "safest and most effective." The decision may be safely left in the hands of the committee if they are in the first place qualified, and in the second place have carefully studied the conditions in each case and fully comprehended their character. In those cases in which sexual perversions are present the operation of vasectomy fails to perform the duty imposed by the law, and experience has shown that in the great majority of cases in which not only future generations are to be benefited by arresting the flow of degeneracy, but also the well-being and welfare of the individual are to be furthered, the operation which accomplishes asexualization, which abrogates the sexual instinct, should be employed.

The operation of vasectomy has been heralded as an "office operation" which inhibits procreation, but does not remove the sexual appetite or the ability to enjoy it. In former publications the writer has called attention to the provisions of the law of Connecticut which forbids under heavy penalty the performance of either operation, vasectomy or oophorectomy, "unless the same shall be a medical necessity," and he commended this provision and advised that it should form a part of every law legalizing surgical operations for the prevention of procreation in every State. The fear was expressed that without restrictions of this kind a class of operators might be created who, in the columns of the public press, would advertise an office operation of vasectomy which would be sought after by the pervert and degenerate who desire to escape the penalties of their unlicensed sexual indulgences and, as well, give to women, by the operation of salpingotomy or salpingectomy, the power to avoid the duty of motherhood.

An important provision of laws enacted for inhibition of procreation in the confirmed criminal and defective classes should relate to the composition of the commission having authority under the law to advise and execute its terms. The executive officers of the institution with the chief medical officer should have the first place, as upon them rests the responsibility of recommendation of those inmates whom they may deem desirable to be submitted to surgical procedures. Next, and most important, in the opinion of the writer is the selection of a skilled neurologist, one who is equipped by experience and expert knowledge with the class of criminals and defectives who are found in public institutions, and in the homes and communities. It is in the particular practice of the neurologist to treat those suffering from mental diseases and from disordered conditions of the nervous system, which are found in the class represented by the idiot, imbecile, epileptic, and insane. His knowledge and experience would make him an important member of the Commission and secure to both the State and to the subject intelligent performance of duty. With the exception of salpingotomy, salpingectomy, or oophorectomy, when the cavity of the abdomen is opened, the surgical operations necessary to produce inhibition of procreation are rather simple in character and may be performed by the surgeon who does the work of the larger towns where, to-day, is usually found a well-organized and well-conducted local hospital. The operations on the male, vasectomy, ligature of the cord, and castration, should command, as in all surgical procedures, great or small, both knowledge and skill on the part of the surgeon.

We may therefore constitute the membership of the Commission charged with authority as follows: (1) The executive and medical officers of the institution; (2) neurologist; (3) surgeon.

Laws enacted by States for the inhibition of procreation should be concisely drawn, stating first the right of the State to enact a law which will inhibit procreation in the confirmed criminal and in the defective subject, in this way protecting the communities of the State against the harmful results which accompany the perpetuation of their kind. Secondly, the classes of criminal and defective subjects and their conditions should be specifically defined. Thirdly, the constitution of the committee which should be charged with the duty of executing the provisions of the law. Fourthly, the character of the penalty which should be imposed for the indiscriminate and unwarranted performance of the operations prescribed in the law and forbidding them unless the same shall be a medical necessity.

The law for the sterilization of feeble-minded (including idiots, imbeciles, and morons), epileptics, rapists, certain criminals, and other defectives enacted by the Legislature of the State of New Jersey and approved April 21, 1911, is here published at length as it varies in such marked particulars from the laws of other States authorizing sterilization in confirmed criminals and defectives with regard to its provisions.

AN ACT to authorize and provide for the sterilization of feeble-minded (including idiots, imbeciles, and morons) epileptics, rapists, certain criminals, and other defectives.

WHEREAS, Heredity plays a most important part in the transmission of feeble-mindedness, epilepsy, criminal tendencies, and other defects:

BE IT ENACTED by the Senate and General Assembly of the State of New Jersey

1. Immediately after the passage of this act, the Governor shall appoint by and with the advice of the Senate, a surgeon and a neurologist, each of recognized ability, one for a term of three (3) years and one for a term of five (5) years, their successors each to be appointed for the full term of five years, who in conjunction with the Commissioner of Charities and Corrections shall be known as and is hereby created the "Board of Examiners of Feeble-minded (including idiots, imbeciles, and morons), Epileptics, Criminals, and other Defectives," whose duty it shall be to examine into the mental and physical condition of the feeble-minded, epileptic, certain criminal and other defective inmates confined in the several reformatories, charitable and penal institutions in the counties and State. Any vacancy occurring in said Board of Examiners shall be filled by appointment of the Governor for the unexpired term.

2. The criminals who shall come within the operation of this law shall be those who have been convicted of the crime of rape, or of such succession of offenses against the criminal law as in the opinion of this board of examiners shall be deemed to be sufficient evidence of confirmed criminal tendencies.

3. Upon application of the superintendent or other administrative officer of any institution in which such inmates are or may be confined, or upon its own motion, the said board of examiners may call a meeting to take evidence and examine into the mental and physical condition of such inmates confined as aforesaid, and if said board of examiners, in conjunction with the chief physician of the institution, unanimously find that procreation is inadvisable and that there is no probability that the condition of such inmate so examined will improve to such an extent as to render procreation by such inmate advisable, it shall be lawful to perform such operation for the prevention of procreation as shall be decided by said board of examiners to be most effective, and thereupon it shall and may be lawful for any surgeon qualified under the laws of this State, under the direction of the chief physician of said institution, to perform such operation; previous to said hearing the said board shall apply to any judge of the Court of Common Pleas, of the county in which said person is confined, for the assignment of counsel to represent the person to be examined, said counsel to act at said hearing and in any subsequent proceedings and no order made by said board of examiners shall become effective until five days after it shall have been filed with the clerk of the Court of Common Pleas of the county in which said examination is held and a copy shall have been served upon the counsel appointed to represent the person examined, proof of service of the said copy of the order to be filed with the clerk of the Court of Common Pleas. All orders made under the provisions of this act shall be subject to review by the Supreme Court or any justice thereof

and said court may upon appeal from any order grant a stay which shall be effective until such appeal shall have been decided. The judge of the Court of Common Pleas appointing any counsel under this act may fix the compensation to be paid him and it shall be paid as other court expenses are now paid.

No surgeon performing an operation under the provisions of this law shall be held to account therefor, but the order of the board of examiners shall be a full warrant and authority therefor.

4. The record taken upon the examination of every such inmate, signed by the said board of examiners, shall be preserved in the institution where such inmate is confined and a copy thereof filed with the Commissioner of Charities and Corrections, and one year after the performing of the operation the superintendent or other administrative officer of the institution wherein such inmate is confined shall report to the board of examiners the condition of the inmate and the effect of such operation upon such inmate. A copy of the report shall be filed with the record of the examination.

5. There shall be paid, out of the funds appropriated for maintenance of such institution, to each phyician of said board of examiners, a compensation of not more than ten dollars ($10) per diem for each day actually given to such work or examination, and his actual and necessary expenses in going to, holding, and returning from such examination.

When in the judgment of the board of examiners it is necessary to secure the assistance of a surgeon outside the medical staff of the institution, to perform or assist in said operation, the necessary expenses of such surgeon shall be paid from the maintenance account of such institution.

6. If any provisions of this act shall be questioned in any court, and the provisions of this act with reference to any class of persons enumerated therein shall be held to be unconstitutional and void, such determination shall not be deemed to invalidate the entire act, but only such provisions thereof with reference to the class in question as are specifically under review and particularly passed upon by the decision of the court.

7. This act shall take effect immediately.

Approved April 21, 1911.

The first clause defines the manner in which the committee of experts shall be appointed by the Governor, said committee to consist of a surgeon and neurologist of recognized ability to act in conjunction with the Commissioners of Charities and Corrections, thus creating a board to be known as the Board of Examiners of Feeble-minded (including idiots, imbeciles, and morons), epileptics, criminals, and other defectives, whose duty it shall be to examine into the mental and physical condition of the feeble-minded, epileptic, certain criminal and other defective inmates confined in the several reformatories, charitable and penal institutions in the counties and State.

The composition of the Committee may be accepted as correct, the addition of the Commissioners of Charities and Corrections being necessary as a representative of the Executive Department of the State, and takes the place of the Executive Officer of Institutions in the laws of other States.

Clause second defines the status of the confirmed criminal as one who has been convicted of the crime of rape or of a succession of offenses against the criminal law which in the opinion of the board shall be deemed to be sufficient evidence of confirmed criminal tendencies.

The first portion of clause third corresponds with the terms which are as a rule incorporated in the sterilization laws of other States, the operation to be performed in inhibiting procreation to be that which the board of examiners shall decide to be the most effective: this is correct and gives proper discretion on a most important point.

The second portion of the clause differs, so far as the knowledge goes, from the provisions incorporated in the laws of any other State. As will be seen its purpose is evidently an effort to protect the inalienable rights of the individual, through the appointment of a legal representative, by a judge of a court, to guard him against any invasion of his rights. Further provisions are included to perfect the legal machinery brought into existence, even invoking an appeal to the power of the Supreme Court to review the orders made under the provisions of the act and grant a stay which shall be effective until the appeal is decided.

In the opinion of the writer the provisions of this law relating to the protection of the criminal and defective subject through the appointment of legal counsel are unnecessary and inconsistent with the purposes of the law which in all respects should be remedial and curable and not *punitive* in character. The court is a medical court before which the subject comes to have decided the question what is best not only for him *personally* but for the *community* in which he lives and for *future generations*.

If the committee appointed under the law is composed, as it should be, of reputable and competent members of the medical profession qualified under the laws of the State it would seem to be sufficient to intrust to their judgment the execution of the provisions of the law relating to the inhibition of procreation in the criminal and defective subjects. It would seem therefore that the provisions of the law which relate to the appointment of counsel and review, if needed, by courts of justice are a reflection upon the character and qualifications of the members of the medical profession who compose a part of the Boards of examiners created under the law. Other States of our country which are without doubt as zealous as the State of New Jersey in protecting their citizens in the exercise of their privileges and rights have not deemed it necessary to place upon their statute books laws with these conditions included. Moreover, it would seem that such conditions would have a tendency to obstruct the execution of the law and defeat its purposes.

In the case of one State in which a law for the sterilization of criminals and defective subjects has been enacted, the writer has been informed by a member of the committee appointed under the law, that the indifference, if not the positive hostility of the executive officers of the public institutions of the State in which these subjects are confined to the execution of the provisions of the law, have prevented the recommendation of any of the inmates for examination by the committee and the performance of such operations as might be needed for their benefit. It would seem, therefore, of paramount importance that penalties should be prescribed for the punishment of those who are able through their positions to violate both the spirit and the letter of the law by their failure to perform their prescribed duties. As stated above, the medical officer through his knowledge is the protector of both the citizens of the State and of the members of the criminal and defective subjects. The private individual without question entrusts to his skill and knowledge the preservation of the health of himself and of the members of his family. In the performance of his duties as officer of the State no higher responsibility can certainly be demanded of him than this.

The following propositions will present, in concise form, the conclusions which may be drawn from the study of the subject under discussion.

1. The State, in the exercise of its duty as guardian of the privileges and of the rights of its citizens, and, as well, charged with the duty of affording protection against conditions which are harmful to its social integrity, has the right to enact laws which will prevent the perpetuation of criminality and degeneracy by inhibiting procreation in the confirmed criminal and in the defective subject.

2. The confirmed criminal and defective subject may be rightfully regarded as in a state of disease, mental, moral, and physical, and therefore the legitimate subjects for medical and surgical treatment.

3. Extended experience on the part of competent students of criminology and sociology confirms the opinion that neither education nor punitive measures are effective in restoring the criminal and defective subject to normal conditions.

4. As heredity is conceded to be an important factor in the perpetuation of criminality and degeneracy through the power of procreation, the fundamental

treatment of these conditions consists in the abrogation of this power.

5. Experience teaches that in many of the criminal and defective subjects inverted or perverted sexual desires and practices are the dominating factors of their disordered conditions. In such subjects remedial and curative results can be obtained only by depriving them through the chosen surgical procedure of the sexual power.

6. That the testes and ovaries produce an internal secretion which is necessary to the normal functioning of the body tissues has been demonstrated. It is believed that after cord or tube ligature sufficient blood supply, through the collateral circulation which is established is distributed to these organs to maintain this secretion.

7. Surgical procedures instituted for the prevention of procreation in the confirmed criminal, pervert, degenerate, idiot, imbecile, epileptic, and vicious insane should not be regarded as a method of punishment but as a remedial measure, the sole objects of which are the betterment of the human race, through the arrest of the continually flowing stream of degeneracy and the mental, moral, and physical improvement of the defective subjects.

J. Ewing Mears.

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**Criminology.**—The science of crime with especial reference to its commission, and the causes and influences responsible for it. Criminal law is concerned with the violation of a written statute; criminology deals with the criminal and his environment. While the studies of criminology deal with subjects who have committed crime, the ultimate aim of the science is prevention and the betterment of conditions, both resulting from improved methods of dealing with infractors of the law. The improvement of these latter must inevitably follow upon a wider and more accurate knowledge of the circumstances surrounding, and principles affecting the genesis of crime. Penology, concerned with the punishment meted out to offenders after the commission of crime, deals, accurately speaking, with a different field.

As a separate science, criminology was developed almost entirely by the work of Cesare Lombroso, the Italian with whose name it is inevitably associated. Professor Lombroso announced in 1876 the discovery of a criminal type and claimed the existence of an instinctive or "born criminal" who could be recognized by certain physical characteristics. Such individuals he regarded as strongly predisposed, if not foredoomed, to crime. The theory met with acceptance and enthusiastic support on the part of many but with the energetic dissent of other scientists. The conflict between the various factions has been vigorous and the consequent developments have been of much interest and value.

It may be pointed out that, if the idea of the born criminal be accepted, the theory of free will in the causation of wrong doing must be abandoned. The criminal impelled to commission by congenital causes beyond his volition or control is therefore placed in the same category as the insane person to whom strictly punitive measures cannot be applied. The opponents of the Lombroso school direct attention to these points and also claim that the existence of a definite criminal type has not been satisfactorily established. This is explained by way of introduction; in order to gain an understanding of the various positions held by the criminologists it will be necessary to examine the history and development of the science.

History.—There was a period preceding the actual genesis of criminology in which was done much work of a preliminary or preparatory character. Three influences contributed in this preparation. First, the effort to correlate characteristics of soul and body which manifested themselves in pseudo-sciences such as physiognomy and phrenology; second, the rise of the science of psychiatry which was to put an end to penal methods with the insane; and third, the development of statistical science. The first of these influences operated in a general way only. The second, the science of psychiatry (*q.v.*), had a very considerable bearing particularly in the formation of the ideas of degeneracy and moral insanity. In the special relations of these latter theories to the criminal the work of Morel, Despine, Thompson, and Maudsley was important. The third influence was the science of statistics which revealed much of value in the study of crime. The work done in this field suggested the idea of the incorrigible criminal and the relation between social data and the incidence of crime. Quételet in 1869 pointed out the "thermic law of crime" which shows crimes of blood to be more prevalent in the south while crimes against property are more prevalent in the north. This was the earliest statement of the relation between physical factors and crime and must be regarded as one of the early milestones of criminology.

During the years between 1871 and 1876 there appeared in Italy several studies of the male offender by a physician, Cesare Lombroso. As time went on his writings attracted more and more attention and eventually made an indelible impression on the opinions and science of criminology. It will be necessary briefly to review Lombroso's position regarding the causation of crime.

In discussing the embryology of crime Lombroso studies crime, or phenomena analogous to it, among the lower organisms, even down to the vegetable world. He then considers it in animals and later among human beings—in both the infancy and the later development of the individual and the species, that is, in infancy and maturity and in a savage and cultured state. There is then developed a type of man called the male offender and distinguished by various characteristics. The conclusion drawn from the observations is that there is in all forms of life a direct relation between criminal acts and the constitution of the organism.

The first explanation of congenital criminality advanced by Lombroso was atavism—that is, reversion to an earlier type from which they have deviated through the influences of intermediate generations. The criminal is considered as going back to the savage type. As de Quirós* has pointed out, this hypothesis of regression to savagery has been developed by (*a*) organic and psychic comparison of the present criminal with the savage and the primitive man, and (*b*) the accumulation of documents showing that, with both the savage and the criminal, crime is not the exception but the rule.

In the criminal Lombroso finds certain anatomical traits, chiefly craniologic, which suggest the structure of primitive men and even of the higher mammalia. Among these traits may be denominated: narrowness of the forehead; exaggerated development of frontal sinuses; a great frequency of median frontal sutures,

* C. Bernaldo de Quirós. *Las nuevas teorías de la criminalidad*. Madrid, 1898. English translation, *Modern Theories of Criminality*, Boston, 1911.

of the median fossa of the occipital crest, and of the Wormian ossicles; abnormal development of the cranial vault; disproportionate development of the mandibles and cheek bones; prognathism; obliquity and great capacity of the occipital orbits and foramen. Among the physiological traits may be mentioned obtuse sensibility, invulnerability and in consequence longevity, absence of vascular reactions, left-handedness. Among the psychological traits are moral and affective insensibility, disposition to idleness, lack of remorse, want of foresight; and among the social traits are tattooing, language, and similar phenomena. That the primitive and savage man is essentially delinquent is supported by physiological, mythological, and historical arguments.

In the Lombrosian theory the criminal is therefore primarily atavistic, a reproduction of the rude morphology of the savage. This alone, however, did not suffice to explain all the findings and observations. According to de Quirós, there remained a few stigmata, crept into the type, which could not be diagnosed as atavistic. Only later did Lombroso see "that these characteristics coincided with those attributed to the morally insane and were connected with other pathological and not atavistic peculiarities. It was only when preparing his study on the epileptic criminal, and at the third edition of his book, that he saw that this family group could perfectly include the born criminal, a discovery that enabled him to solve all difficulties. Nevertheless, in his opinion, atavism did not fail; for there does not exist in pathology any other infirmity more calculated to fuse and combine morbid and atavistic phenomena than epilepsy. The epileptic, for instance, barks and eats human flesh—two marks of prehistoric and savage cannibal atavism." Lombroso thus concluded that epileptic conditions were factors in the causation of crime. But by epilepsy he understands not only the completely developed cases with most apparent symptoms, but also those forms which embrace even the state of temporary insensibility, lack of foresight, or the short choleric and wrathful attacks which indicate the psychic equivalent of muscular epilepsy. This morbid state being the effect of the irritation of the cerebellar or of the medullar cortex, its reaction is characterized by a rapid and excessive discharge of latent forces in intermittent and unstable impulsions.

To recapitulate, Lombroso's theory of criminality is made up of three leading factors: atavism, moral insanity, and epilepsy. His position is summarized by Näcke as follows:

(1) the criminal, properly speaking, is criminal congenitally,
(2) similarly to the moral insane,
(3) on an epileptic basis,
(4) this accounted for mainly by atavism, and
(5) forms a special biologic and anatomic type.

A description of all the characteristics, traits, marks, and stigmata of the "born criminal" would be too extensive to be attempted here. It may be mentioned, however, that in the later stages of Lombroso's work the criminal type which he developed was found to resolve itself into various special types for various classes of criminals (*i.e.* assassins, swindlers, thieves) the differentiation being principally physiognomical.

It will be seen that the theory is based on deep-rooted traits of the individual and its study is practically entirely within the field of anthropology. Lombroso was the leading advocate of the *anthropological theory* of criminality. An evaluation of the theory in the light of its influence will be attempted later in the discussion of present-day standards of criminological science.

Another pioneer in the field of criminology was Enrico Ferri, also an Italian. His work, which is essentially the application of positivistic philosophy to crime and punishment, deserves much more credit than is generally accorded it. His position has exerted, either directly or indirectly, a profound influence on the modern status of the subject. His most important work was the development of his theory of criminal factors. Ferri concluded that "crime is the result of manifold causes, which, although always intricately involved, can be detected by careful study." De Quirós describes his position as follows: "The factors of crime can be divided into *individual* or *anthropological*, *physical* or *natural*, and *social*. The anthropological factors comprise age, sex, civil status, profession, domicile, social rank, instruction, education, and the organic and psychic constitution. The physical factors are: race, climate, the fertility and disposition of the soil, the relative length of day and night, the seasons, meteoric conditions, temperature. The social factors comprise the density of population, emigration, public opinion, customs and religion, public order, economic and industrial conditions, agriculture and industrial production, public administration of public safety, public instruction and education, public beneficence, and, in general, civil and penal legislation. To these factors we could add many others without ever exhausting them, since they include all that the universe contains, not omitting a word or gesture." It will be seen how acute this theory was for the time of its formulation, the year 1881. Ferri also made a study of the varying characteristics and motives of occasional and habitual criminals.

Granting the existence and commission of crime it is necessary that society shall take some steps to protect itself against the consequences. The ordinary police and penal methods are of course instrumental, but there are also, as Ferri points out, what he designates as "penal substitutes." In various fields their influence would be opposed to the criminal factors—physical, individual, and social—already enumerated: Ferri mentions several examples. "Free trade, which prevents exceptionally high prices of food to which are due many criminal agitations; abolition of monopolies, which would prevent smuggling and other kinds of offenses; suppression of certain taxes, which constitute a constant source of agitation; the substitution of gold and silver for bank-notes, for, counterfeit bills being more difficult to detect, it would decrease the number of forgers; cheap workmen's dwellings; preventive and auxiliary institutions for invalids; popular savings' banks, which, by bettering the condition of the poor, would cause a diminution of crimes against property; the construction of wide city streets and better lighting, which render thefts and other offenses more difficult; the spread of the Malthusian laws, which would lessen the number of abortions and infanticides; better civil laws on inheritance, on marriage, on the adoption of natural (*i.e.* illegitimate) children, on the investigation of paternity, on the obligation of making reparation for broken marriage engagements, on divorce, etc., all excellent antidotes against concubinage, infanticide, adultery, bigamy, wife murder, and offenses against chastity; better mercantile laws on the responsibility of the directors of a company, on the procedure of failures, on rehabilitation, etc., thus rendering bankruptcy less frequent; oversight of the manufacturing of weapons in order to reduce the use of these instruments of destruction; courts of honor against duelling; the suppression of pilgrimages; the marriage of the clergy; the suppression of monasteries; the abolition of many holidays; physical exercises; public baths; theaters; foundling homes; the suppression of immoral publications and accounts of famous trials; refusing the young admission to police courts and assizes." Many of these penal substitutes are now being put into operation.

The third leader in the Italian school of criminal anthropology was Raffaelle Garofalo, whose work was evolved from the point of view of a magistrate. The main feature of Garofalo's position was the distinction he made between *natural* crime and *artificial* or *posi-*

*tive* crime, recalling the Roman differentiation between *jus gentium* and *jus civilis*. It is very similar also to the difference between crimes forbidden because they are evil and crimes which are evil because forbidden. To this theory is due the classification of criminals into two groups: the murderers or offenders against humanity, and the thieves or offenders against property. Garofalo also added two other classes: the cynics (to account for sexual criminals), and the violent criminals.

Garofalo was much concerned with the repression of crime. His theory provided for the elimination of the criminal, society developing an artificial system of selection similar to the method operating spontaneously in the biological realm.

The work of the Italian pioneers certainly laid the basis for the new science of criminology. Many of the early findings have since been vigorously attacked; some have been actually disproved. But the activity and the seeming dissensions have been healthy in their effect, and the science has been gaining a firmer and firmer foothold on secure ground. In the evolutionary process a vast number of varying opinions have been expressed and in a small compass it seems almost impossible to give a clear abstract of the different theories advanced. However, as a proper understanding of the main positions is essential to an appreciation of the subject a brief digest will be attempted.

Dealing with the study of the nature and genesis of delinquency, De Quirós has evolved an excellent classification. In the explanation of the system occasional quotations will be made from his summaries.

A. Anthropological Theories:
   *a. Atavistic Theories.*
   *b. Theories of Degeneration.*
      α. Generic.
      β. Specific.
   *c. Pathological Theories.*
      α. Epilepsy.
      β. Neurasthenia.
      γ. Various psychopathic states.
B. Sociological Theories:
   *a. Anthropo-sociological Theories.*
   *b. Social Theories.*
      α. Failure in adaptation.
      β. Segregation.
      γ. Parasitism.
C. Socialistic Theories.

Anthropological Theories.—As has already been indicated, these theories had their genesis in Italy. Lombroso's work in Germany, however, championed by Kurella, did not meet with approval, his findings being opposed by Baer, Näcke, and Aschaffenburg. Not only were the Italian results criticised but the methods followed in obtaining them were severely censured by the Germanic criminologists. But in denying the existence of a criminal type as claimed by Lombroso, a theory of a born or endogenous delinquent was developed. The principal documents of the German school are to be found in the *Archiv für Kriminalanthropologie und Kriminalistik* edited by Hans Gross and in the *Monatsschrift für Kriminalpsychologie und Strafrechtsreform* edited by Gustav Aschaffenburg.

*Atavism.*—Lombroso believed in atavism, that is the recurrence of the criminal to an earlier type. This theory was supported in France by Bordier in a comparative study of the skulls of murderers and of primitive men. Benedikt in Vienna also drew analogies between the brain formation of criminals and conditions existing in the lower animal organisms. The theory is summarized as follows: "Atavism, then, considers the criminal as a retrograde. Phylogenetically, he has been detained in the human or even prehuman evolution; ontogenetically, his arrest has taken place in childhood, granted the parallelism between the evolution of the individual and that of the species according to the law of F. Müller or of Häckel. Lombroso has taken advantage of this in his accessory theory of criminal childhood. According to the latter, as the child in its organic development in the womb presents somatologic characteristics which in the adult would appear as monstrosities, so in the first years of his life he goes through a period of initial perversity—an ontogenetic relic of the primitive immorality of the species—which is overcome or not afterward according to the education received. From this point of view, the born criminal, in whom the primary instincts have not been subdued, continues anomalously in a state of childhood, preserving psychological traits of the child, like impulsiveness, want of foresight, instability, and the like. Granting the metamorphic hypothesis upon which modern anthropology is based, the theory of atavism becomes for nearly all those who accept it prehuman and human as well as organic and psychic. Nevertheless, Colajanni, in his 'Criminal Sociology,' eliminates from the atavistic interpretation all the organic or physical element and reduces it to the simple moral element. According to him, the ethical characteristics would be the only ones to form the retrogressive hereditary transmission, and the criminal would be, morally and not physically, a kind of neo-savage, the relic of times when crime was a physiological state, which turned very slowly into a pathological one."

*Degeneration.*—That the criminal is a victim of generical degeneration is an opinion expressed by various students from Magnan to Dallemagne. It was first stated in a preliminary way by Morel and was later elaborated by Laurent, Magnan, Féré, Corre, Marandon de Montyel, and Dallemagne. "The undeniable fact which constitutes the cornerstone of the theory of degeneration is the reality of the progressive disappearance of races and species through successive and hereditary degradations, occurring, at times, with the most subtle and delicate marks of psychic anomaly scarcely perceptible, and, at other times, showing even the extinction of functions indispensable to racial and individual life. Degeneration is a general phenomenon that can be detected everywhere. But, side by side with it, and showing that its evolution is not fatal, there exist regenerations and regenerating heredities. The phenomenon of criminality has many points of contact with degeneration. As degeneration represents the struggle between the individual and the physical and social environment for the preservation of the individual, so crime represents man struggling against the factors which support order and the progress of societies. Criminal predisposition overlaps degenerative predisposition, the two varying only in degree and manifestations. Each degenerative state presupposes a certain dose of predisposition and of causal intervention; so each crime reveals factors that belong to the individual and influences coming from environment." It must be added, however, that frequently the result of degeneration is opposed to criminal manifestations.

Specific types of degeneration have been advocated by various scientists in explanation of criminality. Marro believed the criminal to be the victim of defective nutrition of the central nervous system. Bonfigli and Kovalevsky traced the condition to defective development of the inhibitory centers. Galton and Ribot believed in a doctrine of moral insanity; sane intellectual faculties but deeply perturbed affective faculties. Virgilio, Dally, Bleuler, Koch, Jelgersma, and Minzhoff advance a theory of criminal neuroses, similar to the Daltonian conception.

*Pathological Theories.*—By several Italian investigators certain criminal characteristics are accounted for by a theory of an epileptoid state. First suggested by Lombroso it has been advocated by Roncoroni, Ottolenghi, Capano, and others.

The explanation of criminality by a neurasthenia theory prevails largely in Germany. First advanced by Benedikt it was later approved by Liszt and Vargha. "What characterizes Benedikt's theory and makes it original is not the primitive atavistic hypothesis which has been alluded to before, but the interpretation of the criminal by means of an innate neurasthenia, a nervous and native psychic debility, and consequently, a rapid exhaustion in all work whether it be physical or mental. Aversion to continual work, frivolity, thirst after low pleasures, and debility in moral struggles, are the result of this state, which is as different from madness as it is from the normal individuality." Various sexually psychopathic states are often regarded as falling under this classification.

The explanation of criminality as due to a synthesis of various psychopathic states had also been advanced, notably by Ingegnieros. This author has developed a system of psychopathology of the criminal which he tabulates as follows:

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| Psychopathology of criminals | Intellectual anomalies (*Dysgnosias*) | Congenital: Criminals through constitutional insanities.<br>Contracted: Criminals through contracted insanity.<br>Transitory: Drunkenness, toxic insanities, etc. |
| | Volitional anomalies (*Dysbulias*) | Congenital: Impulsive epileptic criminals.<br>Contracted: Impulsive chronic drunkards.<br>Transitory: Emotional impulsive criminals, emotional criminals. |
| | Moral anomalies (*Dysthymias*) | Congenital: Born criminals or moral insane.<br>Contracted: Habitual criminals or moral perverts.<br>Transitory: Occasional criminals. |

This completes in brief form an enumeration of the various anthropological theories.

Sociological Theories.—The extreme advocates of the sociological theories contend that crime is always due to external influences of a social character which, far from being the result of individual volition or viciousness, oppose the will of the subject and overcome it inevitably by superior force. From this point of view there is an apparent conflict between the social factors and the obvious anthropological factors which are perceived. The difficulty is solved first by eliminating from a study of criminality the distinctly pathological cases. The idea is that subjects falling within this classification are material for the physician, the hospital, or the asylum, rather than for the cognizance of criminal law, prosecution, and the penal system. The second solution of the difficulty is to regard the physical and anthropological not as factors but as symptoms or marks of the social factor, which alone exists.

*Anthropo-sociological Theories.*—These theories, advocated by Lacassagne, Aubry, Dubuisson, and others may best be represented by a statement of Lacassagne: "Social environment is the heat in which criminality breeds; the criminal is the microbe, an element of no importance until it meets the liquid that makes it ferment," the simile being taken, of course, from microbiology. Aubry, in his "La contagion du meutre" (3rd Edition, Paris, 1895), gives another analogy interesting to the physician and illustrating approximately the same viewpoint. "Long before the discovery of the nature of virulent diseases, it was known that two elements were indispensable for a man in good health to catch cholera, for instance, directly or indirectly from a patient. There was needed a virus—microbes we would say to-day; but neither the virus nor the microbes can always act. Members of the same family may be subjected to the same régime of life for several days, and yet two, three, four of them will be infected, while the others will not, although exposed to the same causes and to the contact of their ill or dead relatives. Why is this? It is because the virulent element has not found in them a prepared soil in which to develop and thrive; while in the others the soil was of the most favorable, and the germs multiplied and soon caused more or less serious disorders. When it is a question of moral contagion, crime for instance, do things happen otherwise? Not in the least. We shall find the same process, with the only difference that we can analyze the noxious elements instead of examining them under the microscope or cultivating them in gelatin."

*Social Theories.*—Criminality is explained by Vaccaro as a lack of adaptation of the individual to social environment. "His starting point is the struggle for existence; but tending to prove 'that the Darwinian laws of selection and of the survival of the fittest, although applicable to human society, and have been until now, are still, and will be for a long time applicable with such restrictions and attenuations, that in most cases, together with a progressive and ascending selection, one meets a reverse process, that is, a descending and retrogressive selection, true degeneration.' As a result of this struggle, crime appears to Vaccaro as an act which the winners who constitute the ruling power consider dangerous to their own interests; the criminal appears as a rebel against the complicated system of domestication by which the winners try to develop only the aptitudes of the domesticated which they can better utilize for their ends; and punishment appears as one of the forces used by them, until, fear having taken root in the nervous cell, it sufficed to substitute the threat of physical pain for the permanent physical correction." The criminal is, under this theory, regarded as a degenerate always from social causes even when showing various physical stigmata.

Aubert developed an opposite idea of segregation rather than alienation. "In his opinion, far from separating himself from the center, the criminal exaggerates the characteristics of the human center and constitutes himself a center for the combined action of phobias and psychoses which represent the mutual action and reaction between the individual and the environment, granted in the former an exhausted or shattered nervous system. For Aubert, phobias are mainly: the feeling of frustrated life, and the fear of poverty and ignominy."

Parasitism as an explanation of the genesis of crime is advanced by Max Nordau. (Une nouvelle théorie biologique du crime, *La Revue*, Paris, 1902.) He explains it simply. "For me, crime means human parasitism, using the word in the analogical and not in the purely biological sense. The condition of the natural and normal existence of man, like that of the other species of somewhat superior animals, is to derive his sustenance from nature, excluding his own species. Wolves do not eat one another, says a proverb which expresses a true biological law. We find very few species among which cannibalism does not appear other than as an exceptional or visible pathological aberration. Man is not a cannibal by nature. Even in the savage state he is never so in his own tribe, although he eats, occasionally, his dead relations. Anthropophagy is only practised with the enemy, who, by an opportune fiction, is not considered as forming part of the same species. Man takes advantage of the animal and vegetable resources which nature offers him. He works for his living and does not beg it of his neighbor. As civilization advances and man is removed from his primitive condition his relations with nature and with other men become more complicated. He can no longer rely altogether on nature for his subsistence. Nature has been confiscated by occupants who utilize it for themselves. Those who own neither land nor

water can obtain provisions only by personal recourse to the usurpers of the land. The division of labor begins. Men organize themselves economically, and production is differentiated and specialized. The family, the tribe, the nation, the entire species becomes a coöperative society in which each member works for all, and in his turn receives from the common production what he needs. Men depend on one another, living thus, a smaller number as usurpers of the soil and a larger one as dispossessed. But this relation does not constitute parasitism; because, with coöperation, there is mutualism. This is the law of the *do ut des;* what I ask of my neighbor I pay by an equal conventional value. Parasitism begins only when, in this coöperative society, there appear men who wish to take without lending anything, and who take away from others the fruit of their labor without their consent and without any compensation. In short, they are men who treat other men as raw material from which they may satisfy their needs and appetites. And the criminals are the ones who precisely fall under this parasitism." A similar viewpoint has also been set forth by Salillas and de Quirós.

Socialistic Theories.—These theories emphasize the transcendent importance of the economic factor in the consideration of social influences. Their advocates charge the economic system of bourgeois society, *i.e.* capitalism, with the causation of delinquency which they claim would almost completely disappear with the advent of a socialistic régime. In the conception of the present penal system as a means for a defense of the class interests of capitalism in a usurpation of the means of production, the source of wealth, and the supply of bread—in this conception we see an expression of the principle of class struggle so vital among the doctrines of socialism. In Italy there has been an active discussion of the extent to which socialism would influence criminality. Colajanni, Loria, Turati, Prampolini, and Zorli have supported the socialistic contention, moderately and in a scientific spirit, but none the less definitely. Lombroso, Ferri, and Garofalo have participated largely in the discussion. It seems that the best way to convey an idea of the situation and the various viewpoints will be to give abstracts from the three leaders in the discussion.

Turati, the most orthodox socialist among Italian criminologists, presents an argument essentially as follows: "Granting that crime be the product of three classes of factors: cosmic or natural, individual or anthropological, and social; granting the five criminal classes enumerated and studied by Ferri—insane or semi-insane, born incorrigibles, emotional criminals, habitual criminals, and occasional criminals—it is evident that the first three, in which the individual factors predominate, could not offend if there existed only physical and social factors, which exercise the main influence in leading the last two classes to crime. Well then, setting aside the influence of the cosmic factors, which, in as far as they form the ordinary environment, cannot, according to Turati, be considered as criminal factors, and which, at any event, exercise only a minimum influence, and that on the quality rather than on the quantity of real delinquency; setting aside also the crimes committed by insane criminals and by those who obey emotional impulse, who, according to Ferri himself, 'are, after all, the least numerous, and represent a ratio which, in spite of all the uncertainty of data on the subject, can be calculated approximately at five per cent. of the total criminality in general,' it follows that the greater number of crimes are those due to social causes and influences. In fact, if the crimes due to a predominant individual element reach forty per cent., we must deduct many exceptions from this figure, and Turati rightly does so, reducing the ratio to about ten per cent. From this the writer deduces that the maximum of criminality, represented by habitual and occasional criminals, is due to social environment; and that, therefore, 'when this environment is modified, when the iniquitous bourgeois society is overthrown and the socialistic ideal is realized, then misery will end, and the motives for crime will be wanting, education ending by turning men into angels' (Zorli). He believes that, once modified, the social environment which makes the citizen, even the small minority of insane and semi-insane criminals, of born criminals, and of emotional criminals will slowly and gradually disappear, because of the better social order, reign of justice, culture, material welfare, and natural selection aided and not hindered."

Enrico Ferri, in his "Socialismo e criminalità" (Turin, 1883), after referring to the three classes of criminal factors says, according to a summary by de Quirós, that "the socialists consider only one of them, namely the class of social factors. Even this is considered through a psychological process—the counter-reaction against individualism—and propaganda strategy. They attribute all the evils and therefore all the crimes to society, overlooking the power and influence of the individual factors. Criminal sociology comes to reëstablish the equilibrium between the two exaggerated currents, assigning to the individual and to society the rôle that belongs to them. Even under a socialistic régime, there would be a social environment, the cause of crime. Setting aside a number of crimes which have nothing to do with the economical social system, as those against honor, insults, etc., of the great categories of crimes—crimes of blood and against the person, crimes against chastity, and those against property—the first two, far from diminishing, increase with economical welfare, and the third could not disappear altogether, since there would never be lacking the kleptomaniacs, the envious of the property of others, and the lazy, who, to avoid the effort of going to the common store-house, would rob their neighbor. In order to gradually overcome crime by bettering the social element, we should make use of the preventive measures of the positivistic school, called penal substitutes. Education, from which socialists expect so much, is of no value and helps only average natures; for it is useless for those who are bad by temperament, and superfluous for the good. The socialists deceive themselves when they believe that under the new economical system of the society which they dream the political and juridical order will be changed; for, if the latter is bound to the former, it is also certain that the former is the effect of the latter, since there is relation in everything, and it is a narrow criterion that looks at things only from one side as socialism does."

Later Ferri's position altered as is indicated by the following quotation: "When poverty and the iniquitous disparity in economic conditions have disappeared, then, through the direct lack of the acute or chronic stimulus of hunger, through the beneficent and indirect influence of better nourishment and the absence of opportunities for an abusive use of power and wealth, there will be a decided decrease and disappearance of those crimes, largely occasional, which in the social environment have a greater determining strength. But this will not cause the disappearance of crimes against chastity through pathologic sexual aberration and others of the same nature. In conclusion, even under a socialistic régime, although in infinitely smaller proportion, there will always be beings defeated in the struggle for existence in the form of the weak, infirm, insane, neurasthenics, criminal, suicidal; and, therefore, socialism does not deny the Darwinian law of the struggle for existence. But it will have such a superiority that the epidemic or endemic forms of

physical and moral human degeneration will be stifled by the elimination of its primordial cause, physical and moral poverty. Under these conditions, the struggle for existence, although remaining the permanent propelling force of social life, will have its course in less brutal and more humane forms, that is to say, intellectual forms and higher ideals. Like physiological and psychic evolution, the struggle will be based on the assurance that every man will receive his daily bread for the body and for the mind."

Colajanni, while holding it an exaggeration to affirm that every social fact—political, religious, esthetic, or moral—is the direct and exclusive product of an economic phenomenon, contends that the social consequences of events are almost always economic. In discussing the direct and indirect influence of the economic factor in its statics and dynamics, he says: "The economic condition exercises a direct action on the genesis of delinquency; for the deficiency of the means to satisfy the numerous necessities of man is a sufficient stimulus for him to adopt honest or criminal methods in the struggle that ensues. These necessities differ according to peoples and are more numerous among those who have reached a higher grade of civilization and possess a larger view of life. Some features of the present economic system give a greater impetus to immoral activity in some determined social circles. In some cases, its positive result is greater, and its danger less than in honorable work . . . . . This feature of the direct influence of the economic system on crimes, especially those against property, is enormous. But the indirect influence is not less evident and powerful. Wars, the present industrial system, the family, marriage, political institutions, idleness and vagrancy, prostitution, education, etc., are so many causes of crime. But each of these in its turn is subject, in a more or less apparent and determined way, to the economic factor, according to the unanimous opinion of thinkers belonging to the most opposite schools; from Morgan to Lacombe, from Marx to Molinari, from Engel to Thulié, from Spencer down to Schäffle, Gumplowicz, Loria, Vaccaro, etc. . . . Suppose alcoholism possessed all the criminal influence attributed to it, to what conditions does this vice owe its allegiance genetically? To poverty . . . . Poverty engenders likewise vagrancy and not vagrancy poverty. . . . . As for prostitution, the greater number of its causes can be reduced to one common denominator: poverty; and its clandestine character 'accompanies the necessity of securing the means of avoiding starvation' (Fiaux) . . . . . The direct relation between poverty, economic misery, and crimes against property is easily perceived; but it is not less real than the relation to crimes against the person, especially through the indirect influence due to necessity and to the degree and kind of education received. It often happens that crimes of this kind, in order to have full course, are combined with the former. There are, moreover, men who confess crimes that they have not committed, in order to escape the imperious necessity of hunger and to be admitted to a prison, where almost always they find board and lodging not rarely better than that enjoyed by the honest workman . . . . . Finally, the doubts concerning the relations between the wealth of a people or of an individual and delinquency disappear when one considers the dynamics of such relations; for one will see that the disturbances in the economic situation are the cause of disturbance in criminal conditions. When the former improves, the number of crimes decreases, and, *vice versa*, when it grows worse there follows an increase in delinquency." It is not possible to enter upon a critique of Colajanni's contentions but it may be said that crimes of blood and of lewdness decrease in hard times and increase during periods of prosperity.

We have thus completed an abstract of the various opinions of criminologists arranged according to one classification. Before passing to more general considerations it may be well to give another well-known classification evolved by Ferri. It is an analysis of theories regarding the genesis and causation of crime.

Crime is a

- Normal . . . . . { Biological phenomenon (Alimena). Social phenomenon (Durkheim).
- Biological abnormality due to { Atavism. Organic and psychic [illegible]. Psychic (Colajanni). Neurosis (Dally, Marro, Maudsley, Virgilio, Jelgersma, Bleuler). Neurasthenia (Benedikt, Liszt, Varghan). Epilepsy (Lombroso, Lewis, Roncoroni). Defect of nutrition in the central nervous system (Marro). Defect of development of the inhibitory centers (Bonfigli). Moral anomaly (Despine, Garofalo).
- Social abnormality due to { Economic influences (Turati, Battaglia, Loria). Juridical unadaptability (Vaccaro). Complex social influences (Lacassagne, Colajanni, Prins, Tarde, Topinard, Manouvrier, Raux, Baer, Kirn, Gumplowicz).

The Modern Consensus.—Having examined the theories advanced by various scholars, we may well inquire what is the modern consensus of opinion regarding the acceptation of the views already set forth? What is the general status of criminological science?

The science is a new one as yet and the question is difficult to answer. Any answer will be open to criticism by various individuals. But some points have been clearly brought out by the weight of authority and a consideration of these will be attempted.

In the first place the exclusively anthropological theories have been rejected. It is established to the satisfaction of most criminologists that there is no "criminal type." Furthermore the atavistic doctrine of the genesis of crime has not stood well under scrutiny. Even if the Lombrosian methods could have withstood criticism, the ethnological evidence has not pointed to characteristics in our earlier ancestors which would correspond to the criminal manifestations of the present time.

The exclusively sociological theories have also failed of acceptation. The factors involved, while undoubtedly important, have not sufficed, as far as the majority of scientists are concerned, to account for the facts.

The consensus rules about as follows: The anthropological factor is important; the sociological factor is also important. The criminal impulse is a resultant of these two components. If the social factor actuating a subject to a criminal act is strong, it will operate affirmatively on many persons comparatively sound individually. If the social factor is relatively weak it will operate only on subjects who are individually decidedly predisposed to crime. This gives us practically a synthesis of the anthropological and the sociological theories.

Practically all crimes can be considered in this light. In a casual theft by a person mentally defective, the individual factor would run high and the social factor correspondingly low. In the theft of food by an industrious mechanic in a period of unemployment due to business depression, the social factor would be all-important; the individual factor of small moment. Various other cases would vary from these in the degree to which the two factors entered respectively.

The Elements of Causation.—To give an idea of the practical elements entering into the two factors

already referred to it may be suggestive to present the classification adopted by Aschaffenburg. *Social Causes of Crime:* 1. Crime and season; 2. race and religion; 3. city and country, occupation; 4. national customs, alcohol; 5. other forms of indulgence; 6. prostitution; 7. gambling and superstition; 8. economic and social conditions. *Individual Causes of Crime:* 1. parentage and training; 2. education; 3. age; 4. sex; 5. domestic status; 6. the physical characteristics of the criminal; 7. the mental characteristics of the criminal; 8. mental diseases among criminals.

The details of these causes may not be given here. They are to be found in more specialized sources; in studies of various subjects—as for instance, trades and occupations, alcoholism, drug habits, prostitution, and general economics.

Accomplishment.—The science of criminology has rendered its greatest service by directing attention to the conditions operating in the causation of crime, and has undoubtedly given a great stimulus to the improvement of these conditions. The science has served to teach the jurist that interest should center, not on the formal infraction of a statute, but upon the personality and motives of the criminal. Finally, it is operating to change the emphasis of the penal system so that a sentence is coming more and more to be intended, not as retribution for an act, but rather as a protection to society with a simultaneous aim of correcting the condition responsible for the crime. This influence is reflected by a consideration of the science of penology (*q.v.*). We are coming to view crime not alone as the product of vicious intent on the part of individuals, but also as the result of defects in the social fabric which we can from time to time alter and improve. Douglas C. McMurtrie.

Literature.

The majority of the scientific contributions to the science of criminology are to be found in the journals representative of the various schools: the Archiv für Kriminalanthropologie und Kriminalistik, edited by Hans Gross, Graz and Leipzig; the Monatsschrift für Kriminalpsychologie und Strafrechtsreform, edited by Gustav Aschaffenburg, Heidelberg; the Archivio di psichiatria, scienze penali ed antropologia criminale, Turin, the organ of the Lombrosian school; and the Archives d'anthropologie criminelle, edited by Lacassagne, Lyons and Paris. There has recently been issued in America a Journal of Criminal Law and Criminology. A bibliography entitled "Preliminary Bibliography of Modern Criminal Law and Criminology" has been issued as Bulletin No. 1 of the Gary Library of Law of Northwestern University. The best general account of the various theories going to make up the science is given by Bernaldo de Quirós, "Modern Theories of Criminality," Boston, 1911. The English translation of this work forms the first volume of "The Modern Criminal Science Series" issued under the auspices of the American Institute of Criminal Law and Criminology. In this same series will be found translations of a number of the standard classics of the subject; among others, Criminal Psychology, by Hans Gross; Crime, Its Causes and Remedies, by Cesare Lombroso; Penal Philosophy, by Gabriel Tarde; Crime and its Repression, by Gustav Aschaffenburg; Criminology, by Raffaelle Garofalo; and Criminal Sociology, by Enrico Ferri.

**Cripples, Care of.**—Cripples constitute a class of persons handicapped by some physical deformity; analogous in type to other classes of physically defectives, as for instance, the blind and the deaf. A cripple is defined by the Oxford Dictionary as "one who is disabled (either from birth or by accident or injury) from the use of his limb; a lame person." The Century Dictionary defines the word as follows: "One who creeps, halts, or limps; one who is partially or wholly deprived of the use of one or more of his limbs; a lame person." But these definitions are lexicographical and to get the true sense of the word, further examination must be made. From the physician's point of view the diagnosis of cripple would, of course, never be made. The patient would be classed as suffering from Pott's disease, club-foot, infantile paralysis, or the like. Yet all these patients are cripples. From this standpoint it is seen that the classification "cripples" embraces collectively persons suffering from various orthopedic defects.

For practical purposes the present writer would define a *cripple* as follows: "A person who by reason of physical deformity or orthopedic defect is prevented from engaging in activities open to normal persons and from availing himself of the advantages and opportunities provided by the community for normal persons." The emphasis is here placed on the status of the subject in relation to the community. This would seem to be justified by two circumstances. In the first place any consideration of the special needs of the cripple is prompted by a consciousness of social responsibility. Further, if we cast our definition in a strictly technical light, we would have to classify as cripples all persons having slight orthopedic defects, such as falling instep. The imposition of a measure of degree by the test of social dependence would seem in keeping with a broad interpretation of the meaning of the word. In this connection it is interesting to note that in a recent symposium of definitions of the word by authorities in Germany (where the most careful attention has been given the subject) a social or economic qualification was included in every definition.

History.—From the earliest times the lot of the cripple appears to have been a hard one, the first mentions of physical deformity implying stigma in other respects as well. Among many primitive peoples the cripple has been very commonly exposed or abandoned to perish of neglect. Deformed or misborn children were destroyed. Among Indian peoples the Chiriguana were addicted to this practice. The Salivas are reported as accustomed to destroy deformed children, attributing the deformity to the influence of evil spirits. A similar practice existed among some tribes in the Antilles. Among the Aztecs deformed persons could be sacrificed in times of famine or need, and also at the death of kings and great men. Deformed infants were abandoned or killed by various tribes living on the islands of the Pacific. Among the Indo-Germanic peoples exposure of deformed babies was a custom of frequent occurrence. In the early law of northern Germany the right to kill crippled persons is often mentioned. There are also instances of similar practices having existed in ancient Persia and Japan, and among the North American Indians.

In a higher stage of civilization the condition of the cripple does not improve to the degree we should expect. Oriental peoples turned their cripples forth to wander in the wilderness. The inhabitants of ancient India cast them into the Ganges; the Spartans hurled them from a precipice. The Jews, in the earliest times, banished their cripples so that they had, perforce, to beg by the roadsides. The general attitude was to regard physical deformity as a blight sent by God or as a punishment for sin. There are various references in the Old Testament to the cripple; *Leviticus* xxi., 16–21; *Proverbs* xxvi., 7; *Job* xxix., 15. The Greeks, worshipping as they did the perfection of bodily form, regarded a cripple as the incarnation of everything unlovely, not only physically but also mentally and morally. Homer describes Thersites as possessed of every ugly attribute and equally deformed in body and in mind.

The advent of Christianity struck a new note in the attitude toward the crippled and deformed. This is referred to in *Isaiah* xxxv., 6; *Matthew* xi., 5; *Luke* vii., 22; *Matthew* xxi., 14; *Acts* iii., 2; *Acts* viii., 7; and *Acts* xiv., 8. But the new influence was not profound and did not permeate even the church itself in its later development. During the Middle Ages, those burdened with physical deformity were considered

as targets for ridicule and contempt, and contumely was continuously heaped upon them. The early Romans had the right to destroy a deformed child, provided the infant were shown by the father to five neighbors and their assent secured. Later even this limitation was removed. Some deformed persons became slaves, in which situation they were intentionally crippled more, in order that they might successfully solicit alms for their master's profit.

During the Middle Ages the chief occupation of the crippled came to be that of court fool or jester. Such characters were found almost universally in the retinues of princes and frequently in the households of noblemen. The system became so firmly entrenched that even a number of decrees passed by the Reichstag in the sixteenth century failed to dislodge it. Not until the time of the Enlightenment was the final stage reached and the custom abolished. Even after this time the court fool was still in vogue in Russia, notably under Peter the Great. When the Spaniards under Fernando Cortez accomplished the conquest of Mexico fools and deformed human persons of all kinds were found at the Court of Montezuma. In the latter part of the Middle Ages, cripples came to be regarded superstitiously. Luther shared the belief current at his time in the theory of changelings. At the birth of an undesirable child it was believed that some diabolical mother had stolen away the right child and substituted her own offspring instead. Cripples, rachitics, and cretins were regarded as changelings. The idea was that, if such children were maltreated sufficiently, their mothers would come again to take them and leave the rightful children in their stead. It is easy to conceive the attitude which such a concept would engender.

*Beginnings of Care.*—The first glimmer of hope for the welfare of the cripple appeared in the eighteenth century, though the progress in this direction was very slow. Some of the old monasteries were reopened and converted into orphan asylums, mad-houses, and penitentiaries. In the establishment of these institutions cripples were frequently considered. Some were provided for in an asylum for pauper invalids, established at Pforgheim in 1722. The monastery of Blankenburg in Oldenburg was converted in 1786 by Duke Peter Frederick Louis into a home for insane persons and cripples. In the middle of the eighteenth century, however, the admission of cripples was discontinued. Such provision for cripples, however, gave them asylum only, and did nothing in a constructive way to better their condition. But the rise of the science of orthopedics caused an improvement in conditions. The theories advanced by the various orthopedists were best put into practice in institutions and a large number of these were founded in the first decades of the nineteenth century. An institution for the deformed was founded at Berlin in 1823 by Dr. J. G. Blömer. It was designed for pay patients from among the upper classes, but indigent crippled children were also admitted. Blömer's opinions regarding education and the social attitude toward cripples were excellent and far ahead of his time. Other similar institutions were founded in Stockholm, Hamburg, and Vienna.

*Modern Institutions.*—In 1832 Johan Nepomuk, a famous philanthropist, founded in Munich the first modern institution for crippled children. Although started under private auspices it was some years later taken over by the State and has since been maintained exclusively at public expense, being one of the few institutions in Europe of which this is true. It is known as the *Zentralanstalt für Erziehung und Bildung krüppelhafter Kinder*. Other institutions were soon founded in Germany. The famous Danish institution at Copenhagen was founded by Pastor Hans Knudsen in 1872 and various other countries soon followed suit. In the United States the first special orthopedic hospital was founded in New York in 1863, the *Hospital for the Ruptured and Crippled*. The first organization devoted in a more particular way to care and education was established in Philadelphia in 1886, the *Home of the Merciful Savior*. The details regarding other countries will be given later in the descriptions of local conditions.

Statistics.—In endeavoring to meet any social problem in a wise and deliberate manner, it is first necessary to know the extent of the problem. Regarding the proportion of cripples in the community and their distribution, however, few data are available as in few localities have any attempts at determination been made. With the blind and the deaf this is not the case as there exist regarding these classes fairly extensive census records. By all means the most important study of the statistics of the deformed was made in Germany in 1906 when all the crippled children under the age of sixteen were enumerated. Data regarding the individual cases were recorded and the cripples were tabulated under different classifications. In all, there were found to be 75,183 crippled children *under* the age of sixteen. In relation to the population this made a ratio of 14.8 crippled children one to fifteen years of age to each 10,000 of population of all ages. Calculated on a basis of proportion to the total population of children within a similar age group (and this gives a more instructive determination) it was found that there were among each 10,000 children 35.73 crippled children. That is, among the juvenile population 0.36 or nearly four-tenths of one per cent. were crippled.

As at best the definition of cripple allows considerable latitude of interpretation, it is fortunate that the compilers of the census classified the individuals approximately according to degree of incapacity. A general division was made under two heads: (1) those not needing resident care (nicht heimbedurftig) designated as N; (2) those needing resident care in an institution (heimbedurftig), designated as H. These headings were still further subdivided as follows:

N Classification.

*No.* Children having orthopedic defect. Needing treatment but not resident care.

*Nk.* Cripples provided for or supporting themselves. Needing neither treatment nor resident care.

H Classification.

*Ht.* Cripples needing institutional treatment and industrial education.

*Hg.* Incurable cripples, incapacitated for industrial education but needing care in a home.

*Hu.* Incurable cripples, requiring prolonged care and provision.

On the basis of these classifications an abstract of the statistics gives the following results:

Crippled Children in Germany.

| Age groups. | N | | N | H | | | H | N + H |
|---|---|---|---|---|---|---|---|---|
| | No | Nk | No + Nk | Ht | Hg | Hu | Ht + Hg + Hu | Total |
| 0–6 years | 4,157 | 1,683 | 5,820 | 7,986 | 906 | 153 | 9,045 | 14,865 |
| 6–15 years | 14,025 | 13,089 | 27,114 | 26,880 | 5,620 | 704 | 33,204 | 60,318 |
| 0–15 years | 18,182 | 14,752 | 32,934 | 34,866 | 6,526 | 857 | 42,249 | 75,183 |
| Cripples 0–15 years to every 10,000 of population | 3.6 | 2.9 | 6.5 | 6.9 | 1.3 | 0.2 | 8.4 | 14.8 |
| Each 1,000 crippled children divided thus | 241.8 | 196.2 | 438.0 | 463.8 | 86.8 | 11.4 | 562.0 | 1.000 |

Regarding the 42,249 crippled children needing resident care, it was pointed out that there were at the time (1906) available in German institutions but 3,125 beds. In the case of 9,388 an active desire for admission to an institution had been expressed. The accommodation for cripples in Germany has since been considerably increased.

The sex distribution showed 39,303 males and 35,880 females. This made the ratio fairly even, in each 1,000 crippled children, there being 522.8 males and 477.2 females.

Crippled Children.—Before proceeding further it may be well to state that in all efforts for the betterment of cripples, attention is directed primarily to the children. With them there are far greater orthopedic possibilities and their minds are plastic enough to benefit from special training. With the great majority of adults the need is principally of employment with a possibility of profit from some form of industrial training. But the crux of the problem, broadly viewed, lies with the children.

Systems of Care.—There are two essentials in the care of crippled children; the first, surgical or orthopedic treatment; the second, training and education. Relatively, surgical or orthopedic treatment must be given priority. It is necessary in all cases of physical deformity and in many instances complete cures are effected, thus eliminating the individual problem and restoring the patient to the ranks of normal healthy persons not needing special care. The physical needs of the cripple, making the strongest appeal to the community, are usually the first provided for. In the beginning this is usually furnished by a hospital or a special department of a hospital. Later on there may be established an independent orthopedic institution. Orthopedics as a science is excellently developed and has many skilled practitioners; the result is that the feature of physical care is reasonably well provided for. In cities where there is no special orthopedic provision, a cripple can obtain treatment at a general surgical hospital or clinic. The trouble with the general hospital, however, is that it is seldom in a position to provide accommodation over the long periods required for the adequate treatment of orthopedic cases.

Treatment may, however, be provided by two methods. The cripples whose condition is acute enough to warrant it or those who are in need of operations may be taken into the hospital as resident patients. But there are some cases not so acute which can be treated with entire success through a clinic or dispensary to which the patients come on certain days, living meantime in their homes. Such an out-patient service permits an institution to care for many more persons than would be possible on the resident plan. It also allows for continued supervision of cases which are convalescent and have been discharged from the wards. In hospitals which have both in-patient and out-patient departments new applicants can be assigned to the one best adapted to their individual requirements.

In some instances the chief need is fresh air and nourishing food. This is best provided by a resident home in the country. Several of the city orthopedic hospitals have country branches to which they send their convalescent patients. This arrangement has proved most successful. There are thus two methods of orthopedic care.

The second essential of care for crippled children, namely, training and education, has been necessarily adapted to meet this classification. We find, therefore, two comprehensive systems of care which have been built up, each equally good. The assignment of crippled children to one or the other is, or should be, based solely on a consideration of individual needs. The systems will be designated as residential and non-residential.

As has been pointed out, orthopedic provision preceded special educational advantages. The first workers in the interests of crippled children frequently found boys and girls fifteen and sixteen years old with no training whatever. Even if cured of their orthopedic deformity they were still handicapped by their total ignorance and incapacity for any useful activity. If their physical defect persisted they were doubly doomed to a life barren of interest and totally unproductive. The reasons for so frequently encountering such a situation are not far to seek. In the first place, the crippled child being unable to leave home was shut in and thus denied the educational advantages provided by the community. Or, secondly, the cripple may have spent long periods in a hospital during which time there was cessation of all educational activity.

In the residential system, classes may be maintained at the hospitals and homes. For the patients of the non-resident clinics and dispensaries there have been inaugurated special day classes for crippled children, either in a special school, or as integral elements of the public school system. Both academic and industrial training may be provided.

It may be mentioned in passing that there are several special methods of work in the interest of crippled children. One is a visiting guild to instruct them in their homes, another is a driving fund which furnishes carriages and omnibuses so that crippled children cared for by various institutions, or not provided for, can be given a breath of fresh air and an afternoon of pleasure. Still another type of work is the provision of teachers who instruct classes for crippled children in coöperation with other agencies.

Principles of Care.—The needs of crippled children are different from those of any other handicapped class. When the crippled child first comes under the care of those working for his welfare, he is usually in an attitude of extreme discouragement and hopelessness. All his life he has had the idea of his uselessness impressed upon him, not necessarily intentionally, but nevertheless inevitably. Each day he has seen his healthy limbed brothers go off to school in the morning, play in the street in the afternoon, and engage in a thousand and one activities which are denied to him. His time has been spent in idleness, and the meaning of childish fun and play has been to him unknown. One can easily imagine the state of mind which such an existence would engender. The first effort therefore in dealing with a crippled child should be to counteract and correct any attitude of discouragement, and to substitute in its place hope and enthusiasm. It is axiomatic that sincere ambition is a prerequisite to all effective endeavor, and this truth holds no less good when applied to the case of the crippled child. If he can be made to feel that life is to be more for him than a dragged-out existence and that there are goals eminently worth striving for which are entirely possible of his attainment, the improvement thus effected will be far from inconsiderable. His view of life will be completely altered and the consequent reaction will be evidenced in every phase of his activity. Much can be accomplished in this direction by personal influence and patient effort to restore the child's self-respect. There are also several impersonal influences of value. The mere bringing to the cripple's attention results achieved by others equally as handicapped as himself is a strong argument, and this is only reinforced by the empirical evidence of his own efforts after his education has commenced.

In work for crippled children carried on under private philanthropic auspices the idea of charity, as far as the child is concerned, should be eliminated to as great an extent as possible. It has long been an established principle of the highest type of human service, that the pauperizing influence of almsgiving in its

earlier sense should be scrupulously avoided. Any feature which tends to remind the children that they are objects of charity emphasizes their natural feeling of dependence and goes a long way toward defeating what should be one of the prime aims of the work.

Primary Education.—The demand of the crippled child for educational advantages is an urgent one. Every argument which can be advanced for the education of normal children—and more—can be urged on behalf of those who are deformed. Starting life with a serious handicap, the only chance for the cripple lies in a thorough preparation for the struggle for a livelihood. For the normal, healthy person education is desirable; for the cripple it is necessary—that is unless he is to be a charge on the community. And this is as undesirable socially as it is uneconomical for the commonwealth. Such a condition is to be avoided as much on utilitarian as on humanitarian grounds. Did the education of the crippled and deformed cost five times as much as it does it would still pay society to provide for this class the best type of educational facilities. In most cases it is possible to change a child from a position of complete dependence into a self-supporting and self-respecting member of the community. The provision, however, is as yet far from adequate.

It is often supposed that crippled children as a rule are mentally defective, or at least inferior in intellect to normal children. In actual practice, however, this has not been found the case. There are, of course, some few crippling diseases which are related to mental defect but these are not numerous. In the various studies which have been made of the subject, the proportion of mentally defective among the cripples might be approximated as ten per cent. In the German census of crippled children, which has already been referred to under the heading *statistics*, an attempt was made to classify the subjects according to mentality and character. The headings are similar to those in the statistical table already cited.

Mentality and Character.

| Classification. | N | | N | H | | | H | N+H |
|---|---|---|---|---|---|---|---|---|
| | No | Nk | No+Nk | Ht | Hg | Hu | Ht+Hg+Hu | Total |
| Of sound mind | 17,729 | 14,510 | 32,239 | 30,009 | 5,715 | 145 | 35,959 | 68,198 |
| Mentally defective | 395 | 204 | 599 | 4,419 | 766 | 697 | 5,882 | 6,481 |
| Tendency to viciousness and crime | 58 | 38 | 96 | 348 | 45 | 15 | 408 | 504 |

The crippled children, however, who are not specifically suffering from mental defect are found to have as acute and extensive an intellectual capacity as any normal children. Their education, therefore, is similar to that provided for normal children with the single exception that, owing to their physical limitations and strength and their varying educational needs, they require more individual attention on the part of the instructor. This requirement is provided for by making classes for cripples smaller as regards number of pupils than classes for normal children in the same school system. The subjects in the primary curriculum remain about the same. It is well, however, owing to the ultimate probable requirements for self-support, that considerable work of a constructive character be given.

Industrial Education.—The subject of industrial education for cripples presents far more difficulties. Much care must be exercised in the choice of trades which are to be taught in order that at the completion of the course the cripple may be able to use his trade as an actual and dependable source of income. Emphasis must be placed not only on the individual capacity of the cripple to engage in the trade chosen, but also on the local employment conditions and the wages available. Thus trades which are distinctly seasonal, giving work at one time of the year and involving idleness at other times, should be avoided, as should also trades which are notoriously underpaid. The great difficulty in this line has been that so many institutions have provided instruction in the "manual training subjects" such as sloyd, basketry, mat-weaving, and the like. These subjects, while excellent to train in the use of their hands children who will eventually take up some entirely different occupation, are practically useless to the cripple who must depend upon the trade he is taught as a means of livelihood. Some forms of embroidery and sewing for girls are subject to the criticism that the occupations are remunerated on a starvation basis.

It is therefore necessary to seek trades in which the training and preparation are of considerable importance and the wages are comparatively high. It is impossible in this article to enumerate or discuss the various possible trades, but as examples of this latter class there might be mentioned type composition, watch-making, and engraving. There are, of course, many others.

American Institutions.—There are, in the United States, a great many more institutions for the care of cripples than is generally realized. This is probably due to the fact that each organization had its inception in the need of a local situation, and was founded to relieve particular conditions. Development was thus along individual lines. There has been no concerted movement for the benefit of cripples, and the institutions which exist are largely ignorant of the work which is being done outside of their own city. There has been no national congress for cripple-care and there is practically no literature by means of which information regarding work and methods might be exchanged. Furthermore, the regular national organizations engaged in philanthropic effort have given no attention to cripples. It might be expected, therefore, that there would be found institutions varying widely in type. This is the case. Some are excellent, others very poor, and there is a great divergence in the ideas regarding the proper methods of care. But just on account of the individuality and the absence of conformity to any exact rules or system, there have been devised several features of great interest.

To the surgeons came the first realization of the special needs of cripples, and the first institution established for their benefit in the United States was the Hospital for the Ruptured and Crippled in New York City. It was found that the proper orthopedic treatment could not be given normally in the regular hospitals, so several surgeons and public-spirited citizens founded the hospital referred to in 1863. Another hospital of a similar nature, the New York Orthopædic Dispensary and Hospital, was founded in 1866. These institutions have done splendid pioneer work along orthopedic lines and are now caring for many patients.

At first, however, these hospitals provided for medical attention only. The first institution founded primarily as a home for cripples was the Home of the Merciful Saviour in Philadelphia, Pennsylvania, 1886. The object was to give care and education to crippled children who were otherwise unprovided for. The next home to be founded was the House of St. Michael and All Angels for Young Colored Cripples, located in the same city. This was started in 1887 to accommodate crippled negro children not cared for in the other home. The Home for Crippled Children in Newark, New Jersey, was founded 1892 and the Daisy Fields Home for Crippled Children in Englewood, New Jersey, was started in 1893.

It must be noted, however, that up to this point the primary object had been either to give purely medical care or furnish a home for cripples. The first institution with a purely educational object was the Industrial School for Crippled and Deformed Children, which was founded in Boston, Massachusetts, by Drs. Bradford and Thorndike, who conceived the idea through becoming acquainted with the institutions in Italy and Germany. The plan of this institution was thoroughly novel as the children lived at home and attended school during the day only, being transported to and fro by carriages. The chief emphasis was laid on industrial training.

The idea of non-resident care and instruction was destined to be carried out in other places and a thoroughly unique system has been developed. In 1898 the New York Children's Aid Society began to establish special day schools for crippled children, the first one being that now known as the Rhinelander School. A few years later the "Avenue B School" was established. In order to provide for the transportation to and from this school there was founded in 1899 an auxiliary organization which later became the Association for the Aid of Crippled Children.

In the meantime, while the non-resident school movement had been gaining headway there had been started an institution which in one particular is absolutely unique. The State of Minnesota established in 1897 a hospital and home for crippled children, which is the only institution in the world started entirely by public initiative. Others, as for instance the Royal Bavarian Institution for Cripples at Munich, have been started by private means and later taken over by the State, but the Minnesota institution was established by the State Legislature. The State of New York followed the example and established the New York State Hospital for the Care of Crippled and Deformed Children in 1900. Massachusetts established a similar institution, the Massachusetts Hospital School, in 1906, and several other States have taken action regarding the welfare of cripples.

Another line of work was opened up in 1906 when the Board of Education of the City of New York opened in one of the public schools the first special class for crippled children, and since then other classes have been formed. Transportation to these classes is provided by two private philanthropic organizations. The City of Chicago has also opened in the public schools special classes for cripples and the transportation in this instance is furnished by the public education authorities.

There has been briefly described the beginnings of the various forms of activity for the care and education of cripples. Along each line great progress has been made and at the present time there is a very encouraging degree of interest. The weakest point in the American situation is the total lack of provision in some sections of the country, notably the South and West.

It will not be possible to describe all the American institutions in detail but the principal ones providing especially for cripples will be enumerated. The order will be according to states. Children's Hospital, San Francisco, Cal. Virginia T. Smith Home for Crippled Children, Newington, Conn. Chicago Public School System—Special Classes for Crippled Children, Chicago, Ill. Happy Haven, 3445 Vernon Avenue, Chicago, Ill. South Side Crippled Children's Aid Society, Chicago, Ill. Home for Destitute Crippled Children, 46 Park Avenue, Chicago, Ill. The Home for Disabled Children, 902 South Eighth Avenue, Maywood, Ill. The Children's Hospital, High and Danforth Streets, Portland, Me. Hospital for the Relief of the Crippled and Deformed of Baltimore City, 2000 North Charles Street, Baltimore, Md. The Children's Hospital, Green Spring Avenue, Baltimore, Md. Massachusetts Hospital School, Canton, Mass. Industrial School for Crippled and Deformed Children, 241 St. Botolph Street, Boston, Mass. New England Peabody Home for Crippled Children, Hale Street, Hyde Park, Mass. Burrage Hospital Association, Boston Harbor, Mass. Van Leuven Browne Hospital-School, 31 Kenilworth Avenue, Detroit, Mich. Special Class, Public School System, Detroit, Mich. State Hospital for Indigent, Crippled and Deformed Children, St. Paul, Minn. The Country Branch of the State Hospital for Indigent, Crippled and Deformed Children, Phelan Park, St. Paul, Minn. Children's Hospital, St. Louis, Mo. Nebraska Orthopedic Hospital, Lincoln, Neb. Home for Crippled Children, Clifton and Fifth Avenues, Newark, N. J. Daisy Fields Home and Hospital for Crippled Children, Central Avenue, Englewood, N. J. New Jersey Orthopedic Hospital and Dispensary, 148 Scotland Street, Orange, N. J. The Children's Sea-shore House, Atlantic City, N. J. Hospital for the Ruptured and Crippled, 321 East 42d Street, New York City. New York Orthopædic Dispensary and Hospital, 126 East Fifty-ninth Street, New York City. The Country Branch and Industrial School, of The New York Orthopedic Hospital, White Plains, N. Y. Hospital for Deformities and Joint Diseases, 1917 Madison Avenue, New York City. Sea Breeze, Coney Island, N. Y. New York City School System—Special Classes for Crippled Children, New York City. The Association for the Aid of Crippled Children, 5 Livingston Place, New York City. Crippled Children's East Side Free School, 157 Henry Street, New York City. Day Home and School for Crippled Children, 2111 Madison Avenue, New York City. Miss Spence School Society, Foot of East Twenty-sixth Street, New York City. Rhinelander School, East Eighty-eighth Street, New York City. Brearley League, New York City. Free Industrial School for Crippled Children, 471 West Fifty-seventh Street, New York City. New York Home for Destitute Crippled Children, 141 West Sixty-first Street, New York City. Visiting Guild for Crippled Children, 33 Central Park West, New York City. Crippled Children's Driving Fund, 105 East Twenty-second Street, New York City. House of St. Giles the Cripple, Garden City, N. Y. Brooklyn Home for Blind, Crippled and Defective Children, Port Jefferson, L. I. Orthopedic Department, St. Mary's Hospital, St. Mark's Avenue, Brooklyn, N. Y. Orthopedic Dispensary, Raymond Street and De Kalb Avenue, Brooklyn, N. Y. New York State Hospital for the Care of Crippled and Deformed Children, West Haverstraw, N. Y. St. Agnes Hospital for Crippled and Atypical Children, White Plains, N. Y. Mrs. Harrison Gray Lamson's Home, 2425 Ocean Avenue, Sheepshead Bay, L. I. Industrial Home for Destitute Crippled Children, 487 Niagara Street, Buffalo, N. Y. Wheel Chair Guild Home, 93 Seventeenth Street, Buffalo, N. Y. Southampton Home for Crippled Children, Southampton, L. I. The Robins' Nest, Tarrytown-on-the-Hudson, N. Y. Home for Convalescent Children, Chappaqua, N. Y. Haxtun Cottage for Crippled Children, Bath Beach, N. Y. Holy Cross House, 5609 Whittier Avenue, Cleveland, Ohio. Rainbow Cottage, South Euclid, Ohio. Willson Avenue School for Crippled Children, Cleveland, Ohio.

Home of the Merciful Saviour for Crippled Children, 4400 Baltimore Avenue, Philadelphia, Pa. The House of St. Michael and All Angels for Young Colored Cripples, Philadelphia, Pa. Widener Memorial Industrial Training School for Crippled Children, North Broad Street and Olney Avenue, Philadelphia, Pa. Summer Home of the Widener Memorial Industrial Training School for Crippled Children, Atlantic City, N. J. University of Pennsylvania Hospital, Orthopedic Department, Agnew Memorial Ward, Philadelphia, Pa. Industrial Home for Crippled Children, 1426 Denniston Avenue, Pittsburgh, Pa. Children's Hospital, Pittsburgh, Pa. Sewickley Fresh Air Home, Sewickley, Pa. Good Shepherd Home, Allentown, Pa. Children's Orthopedic Hospital, Seattle, Wash.

Foreign Institutions.—The provision for cripples abroad according to geographical divisions may now be described, taking up the countries concerned in alphabetical order.

*Austria Hungary.*—In this empire there are several resident homes for crippled children. The system of care, however, is similar to the one in use throughout Germany, which will be discussed later.

*Belgium.*—The most interesting institution in the world for the trade training of adult cripples is located at Charleroi, Belgium. It is an industrial school for the crippled and maimed victims of work accidents, and was founded under public auspices in 1908, through the efforts of a public-spirited lawyer, Paul Pastur. Although the victims of industrial accidents had been assured compensatory indemnity by the Act of 1903, it had been possible to provide only incompletely for the consequences of serious mutilation. The institution has two departments, school and shops. The conditions of admission are: (1) to be crippled by accident or congenitally deformed; (2) to be a Belgian and to have resided in the Province of Hainaut for at least six months; (3) to be twelve years old for admission to the school and at least fourteen years of age for admission to the shops.

The shops in actual operation are: the book bindery, the shoe repairing shop, shop for the manufacture of grass carpet, basket-making shop. The school is made up of the following sections: (1) the section for clerical employees, in which instruction is given in mathematics, bookkeeping, stenography, typewriting, and manual work; (2) the section of apprentice tailors; (3) the section of apprentice saddle and harness makers; (4) the section of apprentice cobblers; (5) the section of apprentice bookbinders.

During their term in the institution both pupils and workers are paid, wages beginning after the first month. If they stay longer than six months they receive pay for the first month as well. The system of instruction is to show the pupils how certain operations should be done, leaving to their own ingenuity the adaptation of the work to the limitations of their individual deformity. A commission is paid the workers on patronage which they secure for the institution. The management is excellent in every detail.

*Denmark.*—The best-known institution for cripples in the world is located at Copenhagen and makes very adequate provision for the physically handicapped in that kingdom—be they children or adults. The importance of the work warrants a full description of its history and extent. On the 21st of October, 1872, Pastor Hans Knudsen founded a society which undertook to care for crippled children. This work, which was established by private philanthropy, was located at Copenhagen, Denmark. According to its constitution, its purpose was to "take care of crippled children and help them to bear their infirmities." The society planned to furnish surgical care and appliances and, to as great an extent as possible, to educate the children with a view to their becoming self-supporting. No children who had passed the age of eighteen were to be received. The founder planned to open a clinic and a school at the same time, so that both types of aid could be combined according to the needs of the individual. The clinical treatment actually began with the founding of the society, while the educational phase of the work was not inaugurated until two years later, 1874, when an annual grant was secured from the government. In 1880 this grant, at the instance of the king, was considerably increased in order that there might be offered equal advantages to adult cripples of both sexes. The age limit, originally placed at eighteen, was thus abolished. In 1884 the number of cripples living outside of Copenhagen had so increased that the ministry gave the society fifty passes on the State railroads in order that such cripples might also be treated at the clinic. In order to secure remunerative work for such pupils as lived in the city and had difficulty in finding employment for themselves, a workshop was established in 1885. Toward the latter part of the same year all the departments were merged and the clinic and school came under the same roof. Knudsen, the founder of the society, died on the 12th of January, 1886. During the next year, 1887, there was added a small ward with several beds so that patients from out of the city might be accommodated when they came for treatment or for the adjustment or repair of their orthopedic appliances. This small ward was the humble beginning of the extensive hospital of to-day. In 1888 there was added a home where pupils from the country might reside during their term of instruction. In 1889 the institution assumed its present name, "Samfundet, som antager sig Vanføre og Lemlæstede" (Society for the Benefit of Cripples and Invalids). In 1895 the boot shop and the bandage manufactory were added to serve the clinic. Another building was purchased in 1896, and still more were acquired later. Facilities for massage and corrective gymnastics followed, and finally the development of the work necessitated the establishment, in 1898, of a primary school for the young cripples of school age.

In 1893 there was opened in conjunction with the institution a summer home, "Børnely," located on the seashore north of Copenhagen. This has since been enlarged and is now open throughout the year.

The object of the society is to provide every necessitous and worthy cripple in Denmark, without regard to sex, age, or type of deformity, with such treatment and instruction as will enable him to earn his living and become a useful member of the community. Only such cripples as can be trained for some work are received; the completely incapacitated are refused, for the institution is in no sense an asylum or almshouse. During the first thirty-five years of the society's existence, it aided 11,749 cripples and invalids. The children were greatly in excess of the adults, the approximate proportion being six to four.

Pursuant to the wish of the founder, the clinic plays the principal rôle in the activity of the institution. During a typical recent year 632 new patients were admitted and treated or instructed free; 349 cripples were treated without full payment or with half payment. There were 12,000 consultations; 250 operations more or less severe were performed upon 160 patients; 111 patients spent 3,063 days in the hospital; 450 pieces of apparatus were applied; 80 patients received massage or gymnastic treatment 3,500 times.

The second principal means which the institution utilizes to bring the cripple to a position of economic independence is the course in the industrial school. The pupils are admitted twice a year for terms which begin the 1st of January and the 1st of August. The course of instruction is four years for male pupils and two and one-half years for female. For the first six months the pupil is taken provisionally. If at the end of this time it is decided that further

instruction would be futile, the pupil is dismissed. If the contrary is decided, instruction is continued in the branch best suited to the abilities of the individual cripple. The instruction is wholly industrial, and when the strength of the pupil permits, the course ends with an official trade examination given under the regular conditions and without reference to the deformity of the pupil.

*England.*—There are two systems of care for crippled children in England—by residential homes and by non-resident day schools. The former system is similar in essentials to the corresponding work in America (*q.v.*) which has been already described. Among the prominent institutions of the residential type in the United Kingdom may be mentioned Lord Mayor Treloar's Home and College at Alton, the Heritage Schools of Arts and Crafts at Chailey in Sussex, and Swinton House, Manchester.

The unique feature of the English situation, however, is to be found in the special classes in the public school system. The first public school class for cripples was opened in London in 1899 to continue, under State auspices, the work then being done by private means at the Passmore Edwards Settlement. In this first experiment the school board furnished instruction only, the settlement providing the premises for the class and the transportation facilities for the children. The following year, the school board passed a resolution in favor of the establishment of separate schools for crippled children of normal intelligence, and since then the number of such schools in England has been growing steadily. It may be explained that all of the English schools are under the general direction of the National Board of Education. This board prescribes certain rules, and schools complying with the regulations are certified as being entitled to receive the imperial grant. In the case of the classes for the elementary instruction of crippled children this grant amounts to fifty shillings a year to each unit of average attendance. For manual instruction a grant of thirty or forty shillings for each pupil per annum is paid, the amount varying with the age of the child. In all cases the remainder of the expense is borne by the local education authority.

One of the most important considerations in connection with the classes for crippled children is the transportation to and from the schools. For this purpose special ambulances and omnibuses are used. The ambulances are so constructed as to allow the insertion overhead of two stretchers for recumbent patients and provide inside seating accommodations for fourteen children in addition to the nurse or attendant. The omnibuses are ordinary stages. Within the jurisdiction of the London county education committee alone, forty-three ambulances and thirty omnibuses are in commission for the transportation of crippled children. A commensurate number of nurses and attendants are employed to accompany the children in these vehicles. For some cases not requiring a special means of transportation tram tickets or carfares are furnished. On account of the circumstances it is impossible to send the children home at luncheon time and they are therefore given a hot meal at the school. In some cities the meals are provided by the school board and in others are furnished by private agencies. The number of pupils to each teacher in the London schools for cripples is shown below for four different years.

| | 1906. | 1907. | 1908. | 1909. |
|---|---|---|---|---|
| Number of teachers | 66 | 90 | 93 | 107 |
| Number of pupils | 1,547 | 2,045 | 2,392 | 2,544 |
| Average number of pupils to each teacher | 23.4 | 22.7 | 25.7 | 23.8 |

The cost of giving crippled children a primary education in the special classes maintained for them varies in different instances. In London during 1909 the average gross cost per capita was $78.45. This included the cost of transportation. For the Liverpool classes the corresponding per capita expenditure for 1909 was $51.34. In Birmingham the cost for each child was $76.40. None of these figures include capital or administrative expenses.

*Finland.*—There are four schools for cripples in Finland. The principal society engaged in the work, the "Föreningen för Lyttas bistånd," was organized in 1889 and established an industrial school at Helsingfors in 1890. At the present time the institution also has hospital facilities. About seventy-five patients are accommodated.

*France.*—In comparison with the other large European countries, the provision for cripples in France is not extensive, and the institutions are not numerous. The work which is done, however, is essentially individual, and thus suggestive. The principal institutions may be briefly described. The home of earliest foundation is the Asile Mathilde in Paris, established 1853. It is managed by sisters of the order of St. Vincent de Paul, is for female cripples only, and accommodates about 300. The purpose is to receive crippled girls above the age of five and supposed to be incurable. The patients are given care and shelter as long as needed. In 1890 the institution was given a country home at Deauville, near Trouville. Religious and secular education is provided, and industrial training compatible with individual capabilities. The girls are skilled in embroidery and the making of artificial flowers.

The Asile des Jeunes Garçons Infirmes et Pauvres, located in Paris, was established in 1858 by the Frères de St. Jean de Dieu. The address of the home is 223, Rue Lecourbe. The object is the reception of crippled children refused as incurable by the general hospitals or denied admission to the public schools. The present accommodation is 400. Surgical treatment is provided, and the work is supplemented by a seaside sanitarium. Industrial training is given in the workshops; about three-fifths of the cripples have been found capable of pursuing a trade. The manufacture of brushes was found unprofitable and was discontinued. Tailoring and shoemaking branches have been especially developed. There is also a bookbinding shop and a shop for printing embossed books for the blind.

One of the most important factors in French work for cripples is the tremendous orthopedic hospital at Berck-sur-Mer. This seaside hospital receives patients from various organizations in Paris and provides the prolonged treatment required. Great emphasis is placed on the curative value of sea baths and there is every facility for keeping the patients out of doors. There are porches outside every ward, onto which the beds may be rolled.

The "Ateliers Departementaux pour les Ouvriers Estropiés, Mutilés, ou Infirmes" were first established in 1889. There are now three such shops. The object of these public institutions is to provide industrial training or employment for the crippled victims of work accidents. The work is similar to that done in the institution already described under *Belgium.*

There are also some institutions, in addition to the general hospitals, which receive cripples though not making a special point of their care.

*Germany.*—The effort properly to provide for the care and education of crippled children has probably been more energetically exerted in Germany than in any other country in the world. The movement started early with the foundation of the Munich institution in 1832 and since that time the homes have grown steadily in number and the standard of work has been raised higher and higher. Furthermore,

this movement in behalf of the cripples has been an intelligent and concerted one. For several years there has been a national society for cripple-care, the *Verein für Krüppelfürsorge*. Since 1900 there has been published a yearbook on the subject, the *Jahrbuch der Krüppelfürsorge*, and since 1908 there has been issued an excellent quarterly journal dealing with the work, the *Zeitschrift für Krüppelfürsorge*. By these means the persons in Germany having in charge the care of cripples have been kept thoroughly informed regarding improvements in methods, and there has been free and constant interchange of experience. This feature of the German work should be especially suggestive to those in America engaged in the same field.

At the end of 1910 there were in Germany fifty institutions for the care of cripples. Of these twenty-six were Protestant, five Roman Catholic, and nineteen undenominational.

In 1910 the accommodation capacity was 4,188, this figure comprising 2,339 males and 1,859 females. The smallest home had six and the largest five hundred beds, the average being one hundred. According to religious affiliation the Protestant homes had 2,819 beds, the Roman Catholic 425, and the undenominational 944. The usual age of admission ranges between fourteen, sixteen, and eighteen. In twelve instances, however, inmates as old as thirty-six are received or there is no age restriction whatever. Almost all the homes charge certain fees for care. This system, however, is designed to place part of the burden of support for the crippled child upon his or her local philanthropic or religious agencies. Thus a crippled child needing care is sent to any one of the homes and the fee paid by the public, charitable, or religious interests most intimately concerned. In the majority of instances, of course, the fee does not begin to cover the expense, the home meeting the difference through endowment or contributions. It is thought in Germany that this system of maintaining a partial local responsibility is of ultimate benefit to the cripple, especially upon returning home after the stay in the institution.

One defect of the German work is the lack of special facilities for the education and care of crippled children by the non-resident system, so successfully operated in England and the United States. It is expected, however, that some efforts in this line will be made in the near future.

The names and location of the institutions referred to are as follows: Wohltätigkeits-Anstalt Bethesda, Angerburg, East Prussia. Diaspora Anstalten (Krüppelheim), Bischofswerder, West Prussia. Berlin-Brandenburg, Krüppel-Heil- und Erziehungsanstalt, Berlin. Krüppel-Pflegeanstalten des Oberlinhauses, Nowawes, Brandenburg, Prussia. Anstalt Bethanien Krüppelabteilung, Fürstenwalde a.d. Spree, Brandenburg, Prussia. Orthopädische Abteilung und Krüppelheim des Paul-Gerhard-Stifts, Berlin. Maria-Victoria-Krüppelheim, Oranienburg bei Berlin. Krüppelheim für Knaben, Alt-Colziglow, District of Rummelsberg, Pomerania. Pommersches Krüppelheim Bethesda im Johanniter-Ordenhause, Zullichow-Stettin, Pomerania. Krüppelheim Wolfshagen, Post Czaycze, Bromberg, Posen. Schlesisches Krüppelheim, Rothenburg O.-L., Silesia. Krüppelheim Bethesda, Marklissa, O.-L., Silesia. Krüppelheim zum heiligen Geist, Beuthen O.-S., Silesia. Krüppelschule Ihrer Durchlaucht der Fürstin von Pless, Waldenburg, Silesia. Pfeiffer sche Stiftungen, Cracau-Magdeburg, Saxony. Krüppelheim des Krüppel-Heil- und Bildungsvereins für den Regierungs-Bezirk Merseburg, Halle a. S., Saxony. Krüppelpflegeanstalt Annastift, Hannover-Kirchrode. Krüppelheim Alten-Eichen, Stellingen, near Altona, Schleswig-Holstein. Johanna-Helenen-Heim, Volmarstein i. W., Westphalia. Orthopädische Heilanstalt Hüfferstiftung, Münster, Westphalia. Josefs-Krüppelheim, Bigge i. W., Westphalia. Vincenz-Krüppelheim, Aachen-Siegel, Rhine District. Westdeutsche Heil-, Bildungs- und Werkstätte für Verkrüppelte Bethesda, Bad Kreuznach, Rhine District. Kinderheim des Vereins für Krüppelfürsorge, Wiesbaden, Hesse-Nassau. Krüppelheim der barmherzigen Brüder, Fulda, Hesse-Nassau. Hessisches Krüppelheim, Nieder-Ramstadt, near Darmstadt, Hesse-Nassau. Hephata, near Treysa, district of Kassel, Hesse-Nassau. Stiftung Dr. Dormagen, Cologne, Rhine District. Königliche bayerische Zentralanstalt für Erziehung und Bildung krüppelhafter Kinder, Munich, Bavaria. Bayerische Genossenschaft des Johanniterordens München, Munich, Bavaria. Krüppelheim von Prof. J. Riedinger, Würzburg, Bavaria. Samariter-Verein für chiurgisch-orthopädische Hilfe, Munich, Bavaria. Beratungsstelle des Vereins für Krüppelfürsorge, Nürnberg, Bavaria. Gustav Werner-Stiftung zum Bruderhaus, Reutlingen, Württemberg. Orthopädische Armenheilanstalt Paulinenhilfe, Stuttgart, Württemberg. A. H. Werner sche Kinderheilanstalt, Ludwigsburg, Württemberg. Verein für künstliche Glieder, Stuttgart, Württemberg. Samariterhaus Reichenberg-Oppenweiler-Backnang, Stuttgart, Württemberg. Samariterhaus Obersontheim-Gaildorf, Stuttgart, Württemberg. Sächs, Krüppelheim Königin-Carola-Stiftung, Dresden-Trachtenberge, Saxony. Krüppelheim, Zwickau-Marienthal, Saxony. Leipziger Heim für gebrechliche Kinder, Leipzig-Eutritsch, Saxony. Kinderheim des Siechenhauses Bethesda, Niederlössnitz, Saxony. Bad. Krüppel-Heil- und Erziehungsanstalt, Heidelberg, Baden. Krüppelheim Luisenhof, Gresgen, Zell i. W., Baden. Landeskrüppelanstalt Elisabethheim, Rostock, Mecklenburg-Schwerin. Herzogin-Elisabeth-Heim, Landeskrüppel-Heil- und Pflegeanstalt, Braunschweig. Marienstift, Arnstadt, Schwarzburg-Sondershausen. Anna-Louisenstift, Blankenburg i. Thür., Schwarzburg-Rudolstadt. Verein Waldecks'che Krüppelhilfe, Waldeck, Schwarzburg-Rudolstadt.

*Holland.*—Provision for cripples began in Holland in 1899 with the establishment of the "Vereenigung tot verzorging van gebrekkige en mismaakte kinderen in Nederland," intended to promote the erection and support of cripples' homes in Holland. Each home so established is independent, and may be denominational, although the Vereenigung is non-sectarian. Since 1900 the Vereenigung has had at Arnhem, the capital of Gelderland, its own institution the "Johannastichting, tehuis voor gebrekkige en mismaakte kinderen gevestigd te Arnhem." In 1907 the institution had seventeen pupils between the ages of nine and twenty-five. In the school the elementary subjects and foreign languages are taught. Industrial training comprises the making of chairs, couches, baskets, and similar articles. The girls learn sewing, cooking, and embroidery.

*Italy.*—The first effort for the benefit of cripples in Italy was shown in 1839 by the opening of an orthopedic institution at Turin. At the death in 1888 of Professor Carbonai, the founder, the institution was closed. Due to the exclusion of rachitic children from the public schools a special class for this type of cripples was opened in Turin in 1872. The children were given surgical treatment as well as education and the experiment was so successful that there was organized a society to promote the establishment of more schools of the same type. In conjunction with the special schools thus established there was founded in 1886 the "Institution for Rachitics." This provides a day school for crippled children in addition to extensive surgical facilities. The pupils who are all young are brought to school each morning in an omnibus and returned home in the same manner. Two meals are furnished at the institution each day.

In Milan a school for rachitics was opened in 1875. This "Istituto pei Rachitici" is made up of school, dispensary, and hospital. The school accommodates

150 children and there are seventy beds in the hospital. There has recently been added an operating-room, a gymnasium, a department of hydrotherapy, and an isolation ward.

Genoa founded a school for rachitics in 1878. This organization maintains a school and dispensary in the heart of the city and a hospital department in the suburbs. The school accommodates between fifty and one hundred and the hospital between twenty and thirty children.

A similar institution was established in 1879 in Mantua. In Cremona another was established in 1881. This latter institution is now an excellent orthopedic hospital. In Bergamo an institution for rachitics was founded a few years later, starting with a dispensary, ambulance service, and school. In 1887 a hospital department was added. In Brescia an institution for rachitic patients was established in 1894. It comprises a school, hospital, and dispensary. Many of the children are dismissed as cured and enter the regular public schools. Between 140 and 160 children are received yearly, fifty of them being cared for in the wards.

In Verona, Venice, Padua, and Modena there are schools or educational institutions for rachitics, having dispensaries but being without hospital facilities. On account of lack of funds but a small number of patients are cared for. There is a seashore home for the rachitics of Padua and a mountain sanatorium for those of Modena.

The most important and widely known institution of this type in Italy is the "Istituto Ortopedico Rizzoli," at Bologna. It was named after the illustrious Bolognese surgeon, Francesco Rizzoli, who in 1880 bequeathed all his estate for the foundation and support of this institution. According to the desire of the benefactor it was to be started in the Convent of the Olivetes, which had been purchased for the purpose by Professor Rizzoli. The institution was to be conducted with three purposes in view: the advancement of science, the good of humanity, and the "welfare and honor of the fatherland."

Nearly fifteen years were spent and $280,000 were expended to restore, remodel, and equip the building. Owing to the natural advantages of the building, at the present time it is excellently suited for the work. Also the rooms are much more generous in size than would have been the case in a new building.

One hundred and fifty beds are provided. Much of the building is given over to large halls in which the patients are able to take all their exercise. One of the largest rooms in Italy, 170 yards long, is on the first floor, and from this one can get some conception of the scale of construction. On the ground floor is a large court enclosed with glass and heated in winter. In other parts of the building are washrooms, a gymnasium, rooms for various orthopedic treatments, laboratories, the library, and the museum. The operating department is large and contains rooms for the use of orthopedic apparatus, as well as rooms in which patients are examined.

The "Orthopedic Institute" in Naples was endowed by the Countess Ravaschieri in 1900. Its work, for which it is excellently equipped, is almost exclusively surgical. In 1906 it acquired a seaside home at Bagioli.

*Norway.*—In Norway there is one institution in Christiania which is the amalgamation of two institutions. "Sophies Minde, Arbeidsskole og Hjem for Vanföre" was founded by King Oscar II. from a fund collected in honor of the fiftieth anniversary of his reign. The corner-stone was laid in 1900. Later this organization absorbed another industrial school for cripples which had been founded in 1892. The capacity is about fifty. The ages of the cripples range from ten to thirty, and in exceptional cases still older pupils are received.

*Russia.*—The care of cripples in Russia has received but scant attention and throughout the empire there are but few agencies devoted to the improvement of their condition. In St. Petersburg there is one institution, however, which has carried the industrial training of cripples to a point which renders it almost unique. It prepares even the most seriously handicapped cripples for a useful occupation, and from this viewpoint its work cannot fail to be of interest to those identified with similar efforts in other parts of the world.

The "Orthopedic Workshop for Trade Training of Cripples" was opened Oct. 14, 1897, under the patronage of Princess Eugenie. The shop is affiliated with the orthopedic department of the Maximilian Hospital.

Instruction in various trades, particularly the manufacture of orthopedic apparatus, was provided. It was found that transportation to and from the workshop each day was a serious problem for some of the cripples, and there was therefore founded in 1901 the "Association for the Care of Cripples Learning a Trade." The object of this organization was to provide a resident home in conjunction with the workshop, and to provide the additional care necessary to train the cripples for careers as industrious workers and useful members of the community.

Cripples between the ages of fourteen and thirty are received for instruction at the workshop. The term of instruction for those with reasonable capacity for work averages about four years. At the expiration of this time if the cripple is in a position to do independent work, even though this work might necessarily be extremely simple, three alternatives are considered: Either he remains in the workshop and receives wages, or remains in the workshop and is partly paid for his labor, or he receives a recommendation and is employed in a private shop.

*Spain.*—So far as can be ascertained there is in Spain no institution for the care and education of cripples. Mendicancy, however, is widespread and some children are intentionally crippled in order that they may more successfully solicit alms.

*Sweden.*—There are four institutions for cripples in Sweden. The "Eugenia-Hjemmet" at Stockholm, founded in 1879, has capacity for 175 crippled boys and girls, the children being received between the ages of two and twelve. Primary and industrial education is provided. In the latter shoemaking and tailoring have proved the most successful trades. The "Föreningen för Bistånd åt Lytta och Vanföra" maintains an industrial school and home at Stockholm with accommodations for thirty-five. In Gothenburg the "Föreningen för Bistånd åt Vanföra" provides an industrial school for cripples accommodating seventy. The boys are taught bookbinding, shoemaking, turning, cabinet-making, basket and brush industries, the preparation of bandages, and wood-carving. The girls are trained in hand and machine sewing, fine needlework, embroidery, weaving, bandage-making, and similar occupations. The "Hjemmet för Vanföre inom Skane" in Helsingborg, accommodating thirty, is for adult cripples who are given industrial training.

*Switzerland.*—There is a national organization in Switzerland to promote the welfare of cripples and to secure for them the erection of homes and schools. There is one institution in Zurich, the "Mathilda-Escher Stiftung." DOUGLAS C. MCMURTRIE.

LITERATURE.

The literature regarding the care and education of cripples is comparatively scanty. It has, however, been fully indexed by Douglas C. McMurtrie in the Bibliography of the Care and Education of Crippled Children, New York, 1913. A special bibliography of American work is appended to an article by Douglas C. McMurtrie on "The Care of Crippled Children in the United States" in the American Journal of Orthopedic Surgery, Philadelphia, 1912, ix., 527–556. There is a special magazine which has given extensive attention to the subject, the Zeitschrift für

Krüppelfürsorge, Hamburg and Leipzig. There is also a yearbook, the Jahrbuch der Krüppelfürsorge, Hamburg. During recent years there have been a considerable number of contributions on the subject to various American medical journals and most of the material to meet ordinary demands can now be found in English. Special papers on the points taken up in the present article can be found through the means indicated.

**Crisis.**—The term crisis has two distinct meanings in medicine:

(1) It is applied to the sudden change which occurs in the course of acute febrile diseases. The crisis is accompanied by a fall in the body temperature, lessening of the pulse rate, and general feeling of improvement; there is often a profuse sweat, and a prolonged and refreshing sleep. The whole should occupy a period of less than forty-eight hours. Crisis may occur in smallpox, pneumonia, measles, relapsing fever, typhus, and remittent fever.

(2) It is also applied to the paroxysmal pains and visceral disturbances experienced in tabes dorsalis (*q.v.*) and in movable kidney (*Dietl's crises*).

R. J. E. Scott.

**Critchett, George.**—Born at Highgate, England, in 1817. In 1839 he was chosen Anatomical Prosector, and, later, Surgeon in the London Hospital; and very soon afterward he began to interest himself in the work of the London Ophthalmic Hospital. In course of time he passed successively through the grades of Assistant-surgeon, Surgeon, and Consulting Surgeon to the latter institution. He was also for some time Ophthalmic Surgeon to the Middlesex Hospital. He died on November 1, 1882. (Pagel.)

Critchett had the reputation of being an eye surgeon of exceptional skill and great inventive capacity. He introduced several new and valuable methods into ophthalmic practice—as, for example, the operation of iridodesis and the mode of enucleating the eye which is the method commonly employed in England. His contributions to medical literature are few in number, and of these the following may here be mentioned: "Lectures on the Diseases of the Eye," *The Lancet*, 1854; "Operation for Strabismus by the Subconjunctival Method," a pamphlet; "Treatise on Linear Extraction of Cataract," 1864 (a most instructive essay); and an article "On the Treatment of the Superficial Affections of the Eye," 1873.

A. H. B.

**Crithidia.**—A genus of flagellate protozoans which stand between *Herpetomonas* and *Trypanosoma*. There are a single flagellum, a short undulating membrane, and two nuclei. The species are mostly parasitic in insects. In their evolutions in culture tubes trypanosomes pass through a crithidial stage, suggesting that *Trypanosoma* has, in its evolution, passed through a *Crithidia* stage. See *Protozoa*.

A. S. P.

**Crockett Arsenic Lithia Springs.**—Montgomery County, Virginia.

Post-office.—Shawsville. Hotel and cottages.

Access.—Via Norfolk & Western Railroad to Shawsville, thence seven miles to springs by conveyance.

This resort is located in the Alleghany Mountains, three miles from the Alleghany Springs. The elevation is 2,150 feet above the sea level, and the atmosphere is pure, bracing, and delightful. The hotel is a new and substantial structure of artistic design, with a veranda encircling the main building, and is fitted up with modern conveniences. Ample provision has been made for the entertainment of guests. There are bowling alleys, lawn tennis courts, and croquet grounds. Walks, drives, fishing, and hunting are also enjoyed, while many find pleasure in rambling through the woods to the famous falls, where a bold and sparkling stream leaps for hundreds of feet from rocks and precipices, forming cascades and sprays of great beauty. The scenery about the resort is romantic and picturesque and affords ever varying features to charm the visitor's eye. The waters of the Crockett Springs are close to thermal, having a temperature of 70° F. in the coldest winter months. The following analysis was made by Prof. Henry Froehling:

One United States Gallon Contains:

| Solids. | Grains. |
|---|---|
| Magnesium carbonate | 1.18 |
| Calcium carbonate | 5.90 |
| Strontium carbonate | .09 |
| Lithium carbonate | .07 |
| Magnesium sulphate | 3.04 |
| Calcium sulphate | 2.25 |
| Potassium sulphate | 1.25 |
| Iron sulphate | .04 |
| Sodium sulphate | 1.86 |
| Sodium chloride | 1.23 |
| Sodium bromide | .01 |
| Sodium arsenate | .02 |
| Aluminum silicate | .12 |
| Silicic acid | 1.29 |
| Barium carbonate, copper carbonate, lead carbonate, zinc carbonate, manganese carbonate, sodium iodide, aluminum phosphate, and ammonium nitrate | Traces. |
| Total | 18.35 |
| Carbonic anhydrides combined with monocarbonates to form bicarbonates | 3.23 |
| Total | 21.58 |

This water is more distinguished for the variety than for the quantity of its mineral ingredients, yet some of its constituents, though minute in quantity, undoubtedly impart to the water an appreciable therapeutic value. It is said that the well-known physiological effects of arsenic, for example, may be readily produced by taking the water in large quantities. In practice the water has been shown to act as an eliminating agent, a nerve sedative, a nerve and blood tonic, and also as an alterative. It has been found particularly valuable in the chronic types of skin disease, especially those characterized by scaly eruptions; also in glandular diseases, rheumatism, gout, diabetes, insomnia, dyspepsia, sea-sickness, disorders of the urethra, bladder and kidneys, chlorosis, general debility, and menstrual disturbances. In those varied conditions in which arsenic is useful the water meets the indications perhaps more promptly, with more permanent results, and with less constitutional and local irritation, than do the artificial preparations of arsenic. The hotel is amply supplied with bathing facilities at any temperature, and good results have followed the conjoint use of the baths and the internal administration of the water. An office has been fitted up for the resident physician by the management, with the latest and most improved electrical apparatus and other appliances for the treatment of chronic diseases. The water is used commercially.

Emma E. Walker.

**Crocus.**—*Saffron; Spanish saffron; Saffran; Stigmata croci.* "The stigmas of *Crocus sativus* L. (fam. *Iridaceæ*), to which is usually attached a portion of the style." (U. S. P.) Saffron should contain not more than fourteen per cent. of water, nor yield more than 7.5 per cent. of its dry weight of ash.

The saffron plant is a perennial herb, resembling colchicum. It grows from a flattened fleshy corm and bears one or two flowers, each possessing a long

thread-shaped style, terminating in three long stigmatic branches. These branches, with a very short portion of the style, are collected and dried and constitute the drug. The nativity of the plant is not certainly known. Cultivated plants yield the whole of the product, which is mostly exported from southern Europe, especially Spain. It grows readily in most warm-temperate regions, but the profitable production of saffron is chiefly a labor problem, since nearly four thousand flowers are required to yield an ounce, and its successful production requires exceedingly low-priced labor.

Description.—Separate stigmas or three attached to a very short portion of their style, each two to three centimeters (about 1 in.) long, flattish-filiform below, dilated and funnel-form tubular above, with the margin irregularly notched; orange-brown, the style portion yellow; texture somewhat cartilaginous, unctuous to the touch, strongly and peculiarly aromatic and bitterish. When chewed it tinges the saliva deep orange-yellow.

So costly a drug is of course subject to numerous and cunningly devised methods of adulteration. It should respond to the following tests:

Sulphuric acid should at once change the stigmas to a blue color, changing to violet, and finally wine-red.

When soaked in water, it should not deposit any pulverulent, mineral matter, nor show the presence of organic substances differing in shape from that described.

On agitating one part of saffron with 100,000 parts of water, the liquid will acquire a distinct yellow color. No color is imparted to benzin agitated with saffron (absence of *picric acid* and some *other coal-tar colors*).

One of the commonest methods of increasing the yield of saffron is that of collecting a large portion of the style with the stigmas, and the possible presence of these styles is referred to in our own and other Pharmacopœias. Onion roots have been chopped up and colored to substitute saffron, as have other fibrous or filamentous bodies. The most important substitute, however, and that very generally sold for saffron in this country, is safflower, which is described under the title *Carthamus*. The detection of adulterants of nearly all kinds is far less easy when the product is pressed into cakes, so that loose or "hay" saffron is always to be preferred. All things considered, the microscope probably offers the most reliable means for detecting adulterants, and a moderately low power suffices for most of them.

Constituents.—Saffron owes its odor to about one per cent. of a volatile oil, which differs considerably according to the method of distillation, being sometimes lighter, sometimes heavier than water. Its color is due to the presence of the yellow glucoside *crocin* ($C_{44}H_{70}O_{28}$), which yields reddish *crocetin*. The name *polychroit* was formerly applied to this coloring matter, but the substance so described was subsequently found to be a mixture, consisting largely of crocin. The bitterish taste of crocus is due to a glucoside which has been called picrocrocin. The other constituents of crocus are unimportant. Crocin is very slightly soluble in water, unless rendered alkaline, but is soluble in alcohol. It becomes blue, then violet-brown with concentrated sulphuric acid, and green, afterward yellow and brown, with nitric acid. The yield of volatile oil is greatly increased by previous treatment with sulphuric acid.

Action and Use.—Crocus has had a wonderful history as a drug. It was credited with remarkable powers by the ancients, and is still so, to some extent, by the more ignorant classes. It, however, probably possesses no other medicinal properties than those of a mild aromatic, stimulant, carminative, and antispasmodic, and may be given in doses of gr. v.–xxx. (0.3–2.0). The Pharmacopœia provides a ten-per-cent. tincture. As used at the present day, especially in the United States, it is almost wholly for the purposes of coloring and slight flavoring.

*Calendula florets* are frequently artificially colored, and loaded with heavy powders, and sold as saffron, either under the latter name, or as "Femmelle" or "Feminelle saffron." Henry H. Rusby.

**Crotalin.**—This is the dried yellow residue of the venomous salivary secretion of the American rattlesnake, the chemical composition of which is not yet accurately determined. But all snake venoms are possessed of analogous physiological properties, and probably the most profound scientific study of this poison was made by Fontana, an Italian investigator, in 1747; and since 1832 it has been given by the mouth in the treatment of various diseases by our homeopathic colleagues. It is, however, the writer's belief that he had the temerity of first administering it hypodermically in treating pulmonary diseases, epilepsy, and various other nervous disorders.

Experiments on animals and snake poisoning in man demonstrate the powerful influence of this secretion on the nervous system, and specifically on the vital centers contained in the medulla oblongata, which coordinate respiration, circulation, and voluntary muscular motion; and on this physiological and pathological foundation this clinical investigation here described has been built, and carried out for nearly six years.

Crotalin has been given in the treatment of pulmonary consumption, acute pneumonia, pulmonary gangrene, asthma, chronic spasmodic cough, chronic aphonia, neuralgia, myalgia, epilepsy, catalepsy, hysteroepilepsy, with satisfactory results.

The back of the forearm is the usual site for its injection although it has been introduced in the neck over the vagi, into pulmonary cavities through the chest-wall, and intravenously, and used as an inhalant.

The appropriate *dose* is of primary consideration in a drug as potent as crotalin; and adjustment of this is sometimes difficult. There is not only a marked variation in the susceptibility of different diseases to its action, but one type of the same disease varies from the other in this respect. As a rule patients suffering from pulmonary affections are less susceptible to it than those having certain diseases of the nervous system, of which epilepsy is a good example, and of which more will follow. Thus most cases of pulmonary consumption do well under beginning doses of gr. $\frac{1}{250}$ or even gr. $\frac{1}{100}$ every four or five days, or oftener, which may be increased in the course of a few months to gr. $\frac{1}{50}$ and even more without detriment.

The following formula has been employed for the preparation of a suitable hypodermic solution of crotalin:

℞ Crotalini . . . . . gr. i.
Glycerini . . . . . ♏ c
Aquæ destillatæ . . . . . ♏ cccc.
M. Sig.—Five minims equal gr. $\frac{1}{185}$.

Crotalin in Chest and Throat Diseases.—The *cough and expectoration* which are prominent symptoms of pulmonary consumption and chronic bronchitis, *hemoptysis and fever*, which are usually present in the former disease, are promptly relieved by injecting from two to five minims of the solution in the arm. *Hoarseness and weakness of the voice, laryngeal and pharyngeal pain, difficult swallowing*, which are some of the most distressing complications of pulmonary consumption, are speedily relieved by injecting two or three minims of the solution over each vagus in the region of the neck. In the *crisis of acute pneumonia*, when delirium is associated with a dry, black, and furred tongue, and the costal movements are dis-

placed by labored diaphragmatic breathing, the writer has observed a crotalin-injection of ten minims (followed by five minims more in five or six hours) bring about a complete reversal of this condition. Most cases of *asthma* are promptly relieved by the neck and the arm methods combined.

The most remarkable case of pulmonary gangrene that the writer has ever known to recover, occurred in a man, aged thirty-nine years, as a sequel to a protracted attack of typhoid pneumonia. When the gangrene developed, the patient was much exsanguinated from repeated hemorrhages, greatly emaciated, partially comatose, had a low muttering delirium, with twitching of the extremities, and picking at the bedclothes. At this point of his disease he received ten minims (gr. $\frac{1}{60}$) of crotalin solution, which was followed by thirteen doses of the same strength on alternate days. He seemed to improve after the first few doses, and in the course of three weeks he made a complete recovery.

Crotalin in Nervous Diseases.—Crotalin has shown itself very useful in the treatment of *trigeminal neuralgia, sciatica, brachialgia, lumbago,* and *intercostal neuralgia.* In the first the writer has seen it fail in some cases, but in others it succeeded well when injected into the arm. In the other diseases mentioned it is injected over the painful spots, except in the last, when the injection is applied over the spinal exit of the affected nerve.

That crotalin has the power of favorably influencing the course and severity of the paroxysms of *epilepsy,* has been too abundantly verified to admit of any doubt. Not only has this been accomplished, but there are a number of cases on record, which, after being subjected to this treatment, have been free from seizures for periods varying from a few months to two years, which is a strong indication that the effects of the drug will become permanent; although the allotted time of four years' freedom from seizures, which is believed by some authorities to guarantee permanency, has not yet elapsed. The probabilities are, however, that the agent which is able to force an armistice for two years is capable of lengthening the truce to the time required.

Reference has already been made to the important subject of the proper dosage of crotalin in treating epilepsy, and in addition it may be said that epileptics who suffer from petit mal seizures, or if these are combined with grand mal attacks, especially if the former predominate, are more sensitive to the action of crotalin, than those who suffer from the grand mal variety alone. This condition demands, therefore, that the dose of the drug be varied in order to meet the difference in susceptibility which pervades these types of the disease. Neglect to bear this point in mind will lead to disappointment. An illustration of this is found in the following history: Crotalin was given in minimum doses to a patient suffering from both types of seizures. So long as he received these doses, the seizures began to diminish in a month, but as the treatment progressed, and the smaller doses no longer produced their former local reaction, which was supposed to be essential to secure the full therapeutic value of the drug, larger doses were resorted to, and in a short time the diminution of the attacks ceased, and became more aggravated than they were before the treatment was started, and the drug was abandoned. A year later the treatment of this case was again taken up with smaller doses, and from last accounts the patient is doing well both mentally and physically.

The average hypodermic dose of crotalin in epilepsy is five minims of the solution (gr. $\frac{1}{100}$, although this amount is excessive for beginning doses in most cases. In patients with the petit mal type of seizures, it is always advisable to begin with one or two minims (gr. $\frac{1}{500}$ or gr. $\frac{1}{250}$), or when the petit mal seizures are very numerous, or the patient is a child, administer half a minim (gr. $\frac{1}{1000}$) every fourth or fifth day. The initial dose should be slowly increased to four or five minims (gr. $\frac{1}{25}$, gr. $\frac{1}{100}$), in the course of six weeks or two months. Continue this dose at the same intervals for a month or two, or longer, and if advisable gradually increase to ten minims (gr. $\frac{1}{60}$), which should not be exceeded in most cases. If at any time during treatment the seizures increase beyond their original limit, the dose must be lowered.

In conclusion it may be said that the question arises whether the bromides enhance the action of crotalin or not. In the writer's early experience it was thought that such a combination was beneficial, but finally it was believed to be of no advantage and the practice was discontinued. The latter deduction seems to be substantiated by the following experience: In one of our institutions for epileptics, fourteen patients received the usual compounds of bromine in connection with crotalin for seven months; and twelve received crotalin alone for the same period. In the former the seizures increased 0.8 per cent., and in the latter they diminished 30.39 per cent. during that time. This would seem to indicate that the bromides hamper the action of crotalin in the treatment of epilepsy.

Thomas J. Mays.

**Crotalus.**—The genus to which the rattlesnakes belong. The tail ends in a rattle formed by remnants of cast skins. The fangs of these snakes are hollow so that they inject poison directly into a wound.

A. S. P.

**Croton Bug.**—An insect, *Ectobia germanica,* belonging to the family *Blattidæ,* which was introduced into this country from Europe. Like many other cockroaches it frequents dwellings where it not only does harm by its voracious eating, but is also suspected of helping to carry some diseases. See *Insects, poisonous.*

A. S. P.

**Croton Oil.**—Oleum Tiglii, Oleum Crotonis. "A fixed oil expressed from the seed of *Croton tiglium* L. (fam. *Euphorbiaceæ*)." (U. S. P.) This species of croton is a small, slender-branched tree, native of China but very largely cultivated in India, and abounding in the East India Islands. The fruit is a three-celled, three-seeded capsule. The seeds are about one centimeter long, oblong, rounded on the back, slightly flattened on the face on each side of the median line, where the raised raphe is to be seen running from end to end. Color of seeds yellowish-brown, black where the outer layer is scraped off, not shining. Testa brittle. Embryo large, albumin oily. In structure and shape they are very much like castor-oil seeds. They are much more uniform in size than the latter, larger than the smallest, smaller than the largest. Taste at first oily, then acrid.

The seeds are used in Java for poisoning fish. They are also largely used in Hindoo medicine, but it is directed that the membrane (tegmen) as well as the testa, and also the embryo, shall be first removed. Besides the oil, they contain *crotin,* a highly poisonous toxalbumin, similar to the ricin of castor-oil seeds The yield of croton oil is about one-fourth to one-third the weight of the seeds. It can be removed with ether or other solvents, though the official requirement is that it be expressed.

Both the seeds and oil are imported from Bombay, Cochin, etc.; the oil is also expressed in Great Britain from seeds imported from the East.

The oil is thus described: "A pale yellow or brownish-yellow, somewhat viscid, and slightly fluorescent liquid, having a slight, fatty odor, and a mild, oily, afterward acrid and burning taste (*great caution is*

*necessary in tasting*). When applied to the skin, it produces rubefaction or a pustular eruption. Specific gravity: 0.935 to 0.950 at 25° C. (77° F.). It reddens blue litmus paper moistened with alcohol. When fresh, it is soluble in about 60 parts of alcohol, the solubility increasing with age. It is freely soluble in ether, chloroform, carbon disulphide, and in fixed or volatile oils. When gently heated with twice its volume of absolute alcohol, it forms a clear solution from which the oil usually separates on cooling. If to 2 c.c. of the oil 1 c.c. of fuming nitric acid and 1 c.c. of water be added, and the mixture vigorously shaken, it should not solidify, either completely or partially, after standing for one or two days (absence of *other non-drying oils*)."

Composition.—This is one of the most complex of fixed oils in composition, and notwithstanding the very extensive study to which it has been subjected, our conclusions are yet far from satisfactory. It dissolves in an equal amount of alcohol, but if this volume of alcohol is increased a portion is insoluble. It is again soluble in 60 parts of alcohol. As the oil becomes older its solubility in alcohol increases, and *pari passu* its irritating properties increase. The most important fact, practically, is that it consists chiefly of a glyceride of crotonoleic acid. This body is purgative, whether in its own state or, as most likely, only through the gradual setting free of the acid in the intestine, is not certainly known. The acid is freely soluble in alcohol, and can thus be removed from croton oil, which always contains some in a free state. It is extremely irritating to the skin and mucous membrane, and it is its gradual formation by decomposition on keeping which renders the older oil more vesicant and more violently drastic. This acid is in a general way similar to ricinoleic acid of castor oil, but is much more active. Glycerides of several other acids, fixed and volatile, have been reported. It is believed that irritating properties reside in some one or more of these volatile constituents, as employees in the factories who do not come into contact with the oil suffer from cutaneous irritation.

Action and Uses.—From the above, it will be seen that croton oil is (1) a vesicatory and (2) a drastic purgative. Upon the skin, a drop to each twenty or thirty square inches produces violent irritation, usually an acute eczematous eruption of numerous closely aggregated blisters, becoming, if the result is intense enough, pustular and scabby. The eruption is usually limited to the region to which the application is made, but in extremely susceptible patients a general vesication of nearly the whole body may follow a limited application. It has been a moderately common mode of counterirritation in bronchitis and other diseases, but is now only rarely used. It has also been used as a parasiticide in obstinate cases. Absorption and purgation have frequently followed its external application.

As a quick purgative, where the most rapid and complete emptying of the bowels is required, in "congestive" and other apoplexies, in injuries to the head, in uremic conditions, in short, whenever an intense derivative action to the bowels is required, croton oil was for a long time at the head of the list; its rapidity of action and the smallness of its dose being great advantages. With the multiplication of purgatives, however, the objectionable features of this oil have led to a steady decline in its use. This is now more generally confined to cases absolutely requiring a powerful local action upon the intestine, such as lead colic or seasickness, or to those in which other purgatives cannot be readily administered, as to individuals who are in a state of insensibility, or to insane patients. Here the dose can be made effective by simply dropping it upon the back of the tongue. The purgative action of this drug is essentially an irritative one, accompanied by griping pain, and often followed by much inflammation. There is increase of watery secretion and also of motion, and any abdominal or rectal irritation or inflammation is markedly increased. It also irritates the uterus, and is abortifacient. These effects may be moderated by washing it with a little alcohol, and thus removing the free crotonoleic acid. The dose is ♏i. to ij. (0.06–0.12) and should not be repeated.

Poisonous symptoms are commonly those of great abdominal inflammation, followed by depression or collapse. In some cases, when purging has not occurred, great depression and progressive blunting of the vital powers have been observed, as is common in the lower animals. Henry H. Rusby.

**Croup.**—*Synonyms*: spasmodic laryngitis; catarrhal laryngitis; laryngitis stridula; laryngospasm; laryngismus stridulus; membranous laryngitis; diphtheritic laryngitis; false croup; true croup; child-crowing; *croup* (French); *Krup, falscher Krup* (German); *laryngite stridula, falso croup, laryngite catarrale spasmodica* (Italian). The word croup is derived from an obsolete imitative verb, *to croup*, meaning to make a croaking sound.

Definition.—Croup is the name given to a symptom common to a large number of diseases and disorders of the larynx, occurring chiefly in childhood, and characterized by the production of a hoarse, crowing, or barking sound, accompanying either inspiration or both inspiration and expiration, and frequently associated with a hoarse, brassy cough.

Description.—Croup is not a distinct clinical entity. As indicated in the above definition it is merely a symptom. The quality of the sound may vary from a slight or marked roughening of the voice to a distinct crowing or barking sound, which in every instance emanates from the larynx, or from the aryteno-epiglottic folds. The word stridor aptly describes this sound. There is no characteristic of this sound by means of which alone one may definitely determine the condition in the larynx which is causing it. The proximate cause of croup is a narrowing of the rima glottidis brought about by an inflammation or edema of the vocal cords, by a spasm of the adductor muscles of the larynx, by various combinations of these conditions, or by the presence of a new growth upon one or both of the vocal cords or upon neighboring structures. In the popular mind the word croup usually signifies a diphtheritic laryngitis. False croup connotes a less serious catarrhal condition

History.—G. F. Still points out that less than a century ago medical writers regarded croup as a disease *sui generis*. Underwood's "Treatise on the Diseases of Children" published in 1784 described "the croup or acute asthma" and also applied to this condition the terms "asthma infantum spasmodicus" and "suffocatio stridula." This author refers to two stages of the disease: the earlier, in which treatment is effective; and the later, in which no treatment is of any avail. This classification, therefore, took account of the wide limits of variation under which this disorder appeared, although the actual pathological conditions underlying it were not recognized. Only one case of croup was examined by this writer post mortem, and in this instance there was found a membrane that extended down the trachea. In 1836 Sir Thomas Watson lectured at King's College, London, on "cynanche trachealis, tracheitis, or croup." He emphasized the epidemicity of croup, and believed that in all cases a membrane is present. Nevertheless, he did not regard croup as contagious, even though he pointed out that certain places as the Cow Gate and Canal Street in Edinburgh were noted for the continued prevalence of croup and for the large number of children that succumbed to it. He contrasted membranous croup with "diphtheritis"

a disease which produced a membrane that appeared primarily on the fauces and only secondarily in the trachea. Charles West who founded the Hospital for Sick Children, Great Ormond Street, differed with Watson in regarding diphtheria and membranous croup as identical. Watson described a "bastard croup" which he stated was characterized by a certain Dr. Good under "the somewhat pedantic and cacophonous title 'laryngismus stridulus'" and by others as "cerebral croup" and "spasmodic croup." West believed that in the early stages of "true croup" the dyspnea is caused chiefly by spasm of the glottis, while later the inflammatory process and the resulting membrane-formation played the chief rôle. West did not recognize simple spasmodic laryngitis as a condition distinct from the diphtheritic form, regarding the difference merely as one depending upon the idiosyncrasy of the patient. The term "laryngitis stridula" was first used by Guersant in 1835 to denote spasmodic croup, which is now recognized under the name "laryngitis stridulosa." Still presents the most modern classification of the conditions of which croup is the prominent symptom as follows: (1) diphtheria, (2) simple laryngitis, (3) laryngitis stridulosa, and (4) laryngismus stridulus.

Classification.—The most satisfactory classification of the disorders giving rise to croup is made by James Frederic Goodhart and George Frederic Still, who divide these affections into two groups, (1) spasmodic and (2) inflammatory. The spasmodic group includes (a) *direct spasm* or laryngismus stridulus, which is chiefly a convulsive manifestation of rickets; (b) *infantile spasm*, or congenital laryngeal stridor, which is caused by a congenital valvular formation of the upper orifice of the larynx; and (c) *reflex spasm*, caused by enlargement of the mediastinal lymph nodes. The inflammatory group includes (a) *catarrhal spasm* or laryngitis stridulosa; (b) *acute laryngitis*, either simple or membranous; and (c) *chronic laryngitis* which is usually syphilitic. Other less frequent causes of croup are papillomatous growths of the vocal cords and the presence of foreign bodies in the larynx or trachea. Goodhart and Still's classification cannot be regarded as a hard and fast one, for in the inflammatory affections of the larynx a spasmodic element is usually superadded. In describing the various conditions in the larynx of which croup is a prominent symptom, the above order of classification will not be followed in this article. The different affections will be discussed in the order of their frequency, which is most probably as follows; (1) catarrhal spasm, (2) acute membranous laryngitis, (3) acute simple laryngitis, (4) laryngismus stridulus, (5) congenital laryngeal stridor, (6) laryngeal spasm in the newborn, (7) chronic laryngitis, (8) stenosis of the larynx, (9) reflex laryngeal spasm from enlarged mediastinal lymph nodes, (10) papilloma of the larynx, (11) foreign bodies in the larynx or trachea, (12) retropharyngeal and peritonsillar abscess, (13) edema of the glottis, (14) submucous laryngitis, and (15) bronchial croup.

Acute Catarrhal Spasm of the Larynx.—*Synonyms:* catarrhal croup, false croup, pseudo croup, spasmodic croup, laryngitis stridulosa.

This is a very common affection of infancy and childhood. It is characterized by the occurrence of repeated attacks of catarrhal inflammation of the larynx accompanied by the sudden onset during the night of a loud inspiratory stridor, which may vary from a mild to a severe type. The child may appear perfectly well when put to bed, but awakens shortly after midnight or in the early morning hours, with a difficulty of respiration. The coarse, stridulous sound accompanies inspiration and is caused by the effort to draw air through the narrowed glottis. There is also a loud, barking, brassy or ringing cough. This may sometimes be followed by vomiting. If the laryngeal obstruction is extreme cyanosis of the face may occur. In rare instances death has been known to occur during one of the attacks. These certainly appear alarming in most cases. Indeed there are few events in the nursery which the parents dread more than an attack of croup. The seizure is usually of short duration. It is accompanied by evidences of catarrhal inflammation of the nose and throat, and by rapid noisy breathing. There is usually a huskiness of voice, but in rare instances there may be complete aphonia. During the attack the child manifests extreme restlessness. If the obstruction in the larynx is pronounced there may develop all the manifestations of air-hunger; the respiration in accelerated, the inspiratory phase is greatly prolonged, the intercostal spaces, the suprasternal fossa, the supraclavicular spaces, and the epigastrium are retracted with each inspiration, the child becomes cyanotic, clutches at its throat, and beats frantically about in bed. This, however, is an unusual picture in catarrhal croup. There are as a rule marked constitutional symptoms. The temperature rises to 103° or 104° Fahrenheit. The height of the temperature is usually an important means of differentiating this condition from diphtheritic laryngitis in which the temperature is as a rule no higher than 102° Fahrenheit. One important characteristic of acute catarrhal spasm of the larynx is the fact that it tends to recur in certain children usually at the onset of cold weather, and again a number of times during the winter. Children with adenoids and hypertrophied tonsils are more subject than other children to the attacks. In some children no predisposing cause can be discovered. Usually a history of exposure can be obtained. There is a pronounced neurotic component in the etiology of catarrhal croup, which in this respect bears a striking resemblance to spasmodic asthma. Undoubtedly in some cases a dietetic disturbance serves as the exciting cause of an attack. The seizure is mostly of short duration, but may be repeated during the night or for the next two or three nights. Following the attack the child may have a hoarse cough, and the temperature may remain high for a number of days.

The *diagnosis* of this condition as a rule presents no difficulty. The recurrence of the attacks in certain children, the suddenness of onset, the presence of a high temperature and other marked constitutional symptoms, and the absence of any false membrane from the pharynx enable one in most instances to rule out diphtheria. Other points in the differential diagnosis of this condition will be discussed in the section on diphtheritic laryngitis. The important features in the differential diagnosis between catarrhal spasm of the larynx and laryngismus stridulus are indicated by the facts that the latter condition occurs in rachitic infants, usually less than two and a half years of age; the attack usually has its onset suddenly during the day, rather than at night; the seizure may be set up by some form of excitation, as fright, anger, etc.; it is not accompanied by fever or by catarrhal symptoms, and is often associated with or followed by general convulsions and unconsciousness. In differentiating between catarrhal spasm and acute catarrhal laryngitis in children, one notes the absence of the sudden spasmodic attacks in the latter condition which is of longer duration and is characterized chiefly by the febrile constitutional symptoms and by the hoarseness of voice, cough, and moderate stridor. Congenital laryngeal stridor may be readily ruled out, for this is a condition persisting from birth and continuing during the early months of infancy. There need be no difficulty in ruling out the chronic conditions such as syphilitic and tuberculous disease of the larynx, and papilloma of the vocal cords, which give rise to a laryngeal stridor and a hoarse cough. The loud barking cough of hysteria may not be as easily excluded. The persistency of the condition, the absence of catarrhal symptoms, the absence of the

acute spasmodic attacks, the detection of hysterical stigmata, and the failure of the usual therapeutic measures, all enable one to diagnose an hysterical affection.

*Prognosis.*—The condition although at times alarming is of short duration. Fatalities are extremely rare.

*Treatment.*—This is both prophylactic and curative. A child subject to frequent attacks of catarrhal croup should be examined with reference to certain physical defects or hygienic errors which may play an important etiological rôle. Hypertrophied tonsils and adenoids which are present in a large proportion of these cases should be removed. Dietetic disturbances should be corrected. The reactive powers of the skin should be exercised by suitable baths. Exposure should be avoided. A prolific cause of attacks of catarrhal croup in infants and young children is the practice of "kicking off the bedclothes." This may be prevented by pinning the infant's sleeping garment at the bottom, or by pinning down the bed coverings. The nursery should not be too warm, efficient ventilation should be provided, but draughts should be avoided. An important point is to prevent the indoor atmosphere from becoming too dry. There can be no doubt that modern methods of heating create an excessive dryness of the atmosphere, which in turn favors the development of catarrhal conditions of the nose and throat. There are a number of mechanical contrivances for maintaining the humidity of the indoor atmosphere. A simple expedient is the hanging of wet towels near the radiator or the hot air inlet, or by having in the room one or more wide shallow vessels of water. The treatment of an attack of catarrhal croup requires the use of measures that will reduce the swelling of the vocal cords, that will relieve the spasm of the adductor muscles of the larynx, and that will liquefy the viscid and dried secretions of this organ. If the attack is a bad one and the child evinces difficulty in breathing, the prompt administration of an emetic such as a teaspoonful of the syrup or wine of ipecac, is usually effective in freeing the throat of the obstruction. Small doses of bromides, and the stimulating expectorants ipecac, squill, and antimony may serve to shorten the attack. Whitla recommends wine of ipecac, wine of antimony, and syrup of squill, of each ten minims every quarter of an hour until the attack is relieved. Warm fomentations to the throat are useful. The atmosphere of the room should be kept moist by means of a kettle of water kept boiling in the room of the patient. To each pint of water there should be added one teaspoonful of compound tincture of benzoin. In those extremely rare cases of catarrhal croup in which suffocation is impending, one should not hesitate to resort to intubation, or if the instruments for this are not available, to tracheotomy.

Acute Simple Laryngitis.—This condition although not as common as the preceding is a more serious one. The period of greatest incidence is from the first to the fifth year of age. It occurs mostly in winter. In older children the disease has the same manifestations as in adults. It is frequently associated with measles, scarlet fever, whooping cough, pneumonia, and diphtheria. It may be associated with simple coryza, or nasopharyngitis, tracheitis, or bronchitis. There is a variable degree of congestion and swelling of the epiglottis and of the mucous membrane of the larynx. In the milder cases there are a slight cough, hoarseness, partial or complete aphonia, and mild constitutional symptoms. The condition lasts from four to ten days. In severe cases the symptoms may develop gradually or may have a sudden onset. There are a hoarse, barking cough, a hoarse voice, stridulous breathing, and dyspnea. Severe paroxysms of dyspnea may occur, mostly at night. The stridor is chiefly inspiratory, but may be identical with that of membranous laryngitis. The constitutional symptoms are more or less severe, the temperature sometimes rising to 104°. The symptoms continue for two or three days, after which they gradually subside. During the period of invasion of measles there occur frequently a laryngeal cough and stridor which resemble closely those of acute catarrhal spasm and acute laryngitis. One of the complications of varicella is laryngitis and tracheitis (varicellar croup).

*Diagnosis.*—The important point is to exclude the possibility of a diphtheritic laryngitis. The differential diagnosis is discussed under the latter condition.

*Prognosis.*—In rare instances death may occur from acute stenosis of the larynx. The large majority of cases recover in from a few days to two weeks. In some cases the inflammatory process may extend into the bronchial tubes, and may even result in a bronchopneumonia.

*Treatment.*—This is nearly the same as that of acute catarrhal spasm of the larynx. The child should be kept in bed, in a well-ventilated room, and steam should be generated by means of a kettle of water kept boiling in the room, or may be conducted by means of a long spout or rubber tube from the kettle underneath an improvised tent over the child's bed. The mouth of the spout or tube should not be brought too close to the face of the child, for fear of scalding the latter. A hot mustard foot bath is useful at the beginning of the attack. The bowels should be opened with small doses of calomel. Small doses of aconite are effective, and antipyrine may serve to control the laryngeal spasm. Stimulating expectorants and emetics find the same indications as in catarrhal spasm of the larynx. Hot formentations may be applied to the throat. In extreme cases of dyspnea it may be necessary to resort to intubation or tracheotomy.

Acute Membranous Laryngitis.—*Synonyms:* diphtheritic laryngitis, diphtheritic croup, true croup.

This condition is not exactly synonymous with diphtheritic laryngitis, for there are cases, of course extremely rare, in which a membranous inflammation of the larynx may be caused by the staphylococcus and other microorganisms. Moreover caustic agents such as phenol, potassium hydroxide, etc., may cause a membranous inflammation of the larynx. But the overwhelming majority of all cases of membranous laryngitis are caused by the Klebs-Loeffler bacillus. The affection is rare from the first to the seventh month of life, after which its incidence increases up to the first year when the maximum of frequency is attained. This maximum is continued until the second year of life after which the frequency gradually diminishes up to the fifth year. After this period the incidence rapidly diminishes. The curve of mortality is parallel to the curve of incidence. The mortality varies in different parts of the world and at different times. The average mortality is about 25 per cent. Diphtheritic croup is more frequent among males than among females. It is relatively more common in rural than in urban communities. The incidence and mortality are in general greatest during the period from December to March, and least during the summer months. The epidemicity of diphtheritic croup is subject to certain unknown factors. In certain years there is a greater proportion of laryngeal cases of diphtheria when compared with pharyngeal cases than in other years. Alfonso Montefusco made a study of 2,464 cases of diphtheritic croup that were under observation from 1902 to 1912 in the Cotugno Hospital of the city of Naples. During this period there were under observation in the same hospital only 539 cases of diphtheria in which the larynx was not affected. This predominance in the number of laryngeal cases over the pharyngeal cases represents a most unusual occurrence, for as a rule the cases of laryngeal diphtheria represent but a small percentage of all cases of diphtheria.

Diphtheritic laryngitis is as a rule the result of the extension downward of the diphtheritic membrane from the pharynx into the larynx. In these cases the membrane formation may continue into the trachea. In an extremely small proportion of cases the laryngeal diphtheria may be primary; the process may be confined to the larynx, or it may extend upward into the pharynx. The recognition of laryngeal involvement in a case already diagnosed as pharyngeal or tonsillar diphtheria is not difficult. The gradual development of huskiness of voice, and of stridor which affects both inspiration and expiration furnishes unmistakable evidence that the diphtheritic process has invaded the larynx. If this process is not checked by or in spite of the adequate administration of antitoxin, the voice becomes more and more husky and is finally lost, and the stridor increases in intensity. Within a few days, and sometimes within a few hours the laryngeal obstruction becomes so pronounced as to lead to violent efforts to get air. In addition to the obstruction produced by the presence of the membrane on the vocal cords, and above and below the larynx, there is considerable spasm of the adductor muscles of this organ. In some cases the spasmodic element predominates. In the course of the gradually developing stridor, dysphonia, and dyspnea, there occur sudden exacerbations of all of these symptoms. These exacerbations at first occur at intervals of hours. Later the intervals are shorter, until the attacks occur every few minutes. Fright may precipitate one of the attacks. Usually all of the symptoms are of gradual onset, but sometimes sudden dyspnea and acute suffocation may occur in a child apparently well, or under treatment for a slight cold. Whether the symptoms are of gradual or sudden onset, or whether they represent an exacerbation, the clinical picture in an unrelieved case is always the same, although differing in intensity. The stridor is characteristic. The loud, laryngeal breathing in which both the inspiratory and expiratory phases are prolonged; the more or less complete aphonia; and the occasionally husky or barking cough are sooner or later followed by a sudden onset of dyspnea. The accessory muscles of respiration are called into play. The intercostal spaces, the suprasternal fossa, the supraclavicular regions, and the epigastrium are retracted with each inspiration. All of the manifestations of air-hunger arise. The child's face becomes livid. He clutches at his throat. He throws himself about in bed. If the obstruction is not relieved the extreme restlessness is followed by convulsive movements of the body, coma, and finally death. The condition is one of acute asphyxia. In most instances, fortunately, the fatal termination is prevented by the expulsion during a violent act of coughing of a portion of the obstructing membrane from the larynx. Occasionally a complete cast of the larynx and trachea is expelled. In infants the progress of the disease is rapid, death occurring in from thirty-six to forty-eight hours from the beginning of the symptoms. In older children the attack lasts from two days to a week, death resulting from bronchial croup or pneumonia.

The *diagnosis* of a case of diphtheritic laryngitis is not difficult provided one perceives the development of laryngeal obstruction in a case already recognized as one of pharyngeal or nasal diphtheria. On the other hand the diagnosis is not a simple one if the diphtheritic process is primary in the larynx, that is, if it starts in this organ, remains confined to it, or has not yet spread to the pharynx. In the early stage of a primary laryngeal diphtheria, there may be no means, apart from direct laryngoscopic examination (which in the child and under the circumstances is extremely difficult), of differentiating the condition from an acute simple laryngitis. The hoarseness of voice, the slight cough, and the moderate stridor are common to the two conditions. Both develop gradually. There may be little constitutional disturbance in either condition. But the main difference between the two conditions is that in a case of diphtheritic laryngitis the dyspnea is constant, steadily increases, and affects both inspiration and expiration. In acute simple laryngitis the dyspnea is paroxymal, and is more apt to be worse at night. The loss of voice is not as pronounced as in diphtheria and the temperature is apt to be higher. In diphtheritic laryngitis there may be evidences of general toxemia: the pulse is more rapid; there is a marked cutaneous pallor; there is more or less complete anorexia; there may be a characteristic fetor to the breath; and there may be albuminuria. In diphtheritic laryngitis there is usually an enlargement of the cervical lymph nodes. A culture taken from the pharynx may show the Klebs-Loeffler bacillus. The knee-jerks may be absent. In primary diphtheria of the larynx there may be little evidence of general toxemia on account of the slow absorption of toxins from the larynx, and the obstructive symptoms predominate over the constitutional ones. The therapeutic test, *i.e.* the prompt effect of the adequate administration of antitoxin may alone enable one to decide as to the real nature of the condition. From a case of acute catarrhal spasm of the larynx the diagnosis is not so difficult. The latter is of sudden onset in a child that may have been subject to similar attacks. There is a marked rise of temperature. There may be none of the above symptoms characteristic of diphtheria. The greatest difficulty in diagnosis arises when diphtheritic laryngitis occurs in a child that has been subject to attacks of acute catarrhal spasm of the larynx; in fact, both conditions may coexist. From laryngismus stridulus and from congenital laryngeal stridor the distinction may easily be made.

*Prognosis.*—The mortality in diphtheritic laryngitis is high, being 25 per cent. even with the most effective antitoxic treatment. This high mortality is to be attributed not to the greater virulence of the bacterial infection in the case of diphtheritic involvement of the larynx, but to the anatomical conditions which render so ominous even a mild membranous invasion of the larynx. The mortality is greater the younger the child. It is higher in males than in females. It is greater in some epidemics than in others. The administration of antitoxin and the employment of intubation have effected a marked reduction in the mortality. The statistical investigations made by McNaughton and Maddren of Brooklyn, in 1892, of 8,383 cases of diphtheritic laryngitis, showed that in 2,417 cases tracheotomy was performed, with 24.2 per cent. of recoveries; and with intubation was performed in 5,546 cases with 30.5 per cent. of recoveries. Ranke of Munich reported in 1893 the results obtained in 1445 cases of intubation in Germany: there were 38 per cent. of recoveries. Calomel fumigations further reduced the mortality. Dillon Brown in 1894 reported 490 intubations without calomel fumigations with a mortality of 65.2 per cent.; and 279 intubations with calomel fumigations, with a mortality of 50.6 per cent. The introduction of antitoxic treatment still further reduced the mortality. A report of the American Pediatric Society of 533 intubated cases in which antitoxin was used showed a mortality of 25.9 per cent. The figures, already quoted, of Montefusco, show a mortality of 25.3 per cent. in 2,464 cases of laryngeal diphtheria treated in Milan from 1902 to 1912. The recent early employment of massive doses of antitoxin should cause a greater reduction in the mortality.

*Treatment*—Every case of diphtheritic laryngitis should receive at once a dose of 10,000 to 20,000 units of antitoxic serum. The intravenous method of administration is regarded as the most rapid in its action and as the most effective. The dose should be repeated at the end of twelve or twenty-four hours, depending upon the results. It is better to give one large dose than several smaller ones. (See *Diphtheria.*)

As an additional measure calomel fumigation should be employed. Ten or fifteen grains of calomel should be volatilized by means of a suitable fumigator, in a tent composed of a sheet enveloping the child's bed. If the respiratory difficulty gets progressively worse as evidenced by an increasing dyspnea and cyanosis, and by a retraction of the intercostal spaces and of the epigastrium, one should not wait for fatal asphyxia before resorting to intubation. (See *Intubation.*) If the instruments for intubation are not available, one should not hesitate to perform the operation of tracheotomy.

Laryngismus Stridulus.—*Synonyms:* laryngospasm, direct spasm of the glottis, cerebral croup. This condition is characterized by the occurrence of sudden attacks of apnea, followed by a long, loud, crowing inspiration. The attacks occur mostly in infants less than eighteen months of age, who are either rachitic or affected with spasmophilia. (See *Spasmophilia.*) In the latter condition there is an increased irritability of the nervous system which manifests itself in the occurrence of various kinds of convulsive seizures. Laryngospasm is one of these. Tetany is another manifestation. General convulsions are frequently associated with laryngismus stridulus. A typical attack of this condition is described by West as follows: "The child throws its head back, its face and lips become livid, or an ashy pallor surrounds the mouth, and slight convulsive movements pass over the muscles of the face. The chest is motionless, and suffocation seems impending. But in a few moments the spasm yields, expiration is effected, and the crowing inspiration succeeds." The attack is brought on usually by some excitement. The child may be otherwise apparently healthy. The inspiratory crow following the period of apnea has been likened to the whoop of pertussis, without, however, being preceded by the violent cough, and being less noisy and prolonged. The attack is followed by a spell of crying, a state of fretfulness or of irritability, or a general convulsion, or the child may return to its former condition of apparent well-being. In rare instances death may occur during the attack.

The *diagnosis* is not difficult. It depends upon the recognition of the peculiar character of the attacks, their occurrence at irregular intervals in rachitic, or spasmophilic children, and the absence of catarrhal or febrile symptoms.

The *treatment* consists in combating the constitutional condition by suitable hygienic, dietetic, and medicinal measures. Following an attack the bowels should be opened with calomel, and bromides with or without chloral should be administered.

Congenital Laryngeal Stridor.—This condition is occasionally observed in young infants in whom it has existed from birth. It consists of a noisy or stridulous breathing, affecting usually inspiration only, but sometimes affecting both inspiration and expiration, and occurring whenever the child is excited, when it is taken from a warm to a cold atmosphere, when it awakens suddenly from sleep, and when it cries. In other cases the condition is more or less constant, although of varying intensity. It is more common in girls than in boys. Still states that in most of his cases the stridor was compared to the noise made by a hen in "clucking," while in other cases the sound was called "croaking" or "crowing." The actual cause of this condition is still subject to differences of opinion. The most probable cause is an excessive elongation and recurvation of the epiglottis, which is bent inward half down the middle, so that the aryteno-epiglottidean folds are brought almost in apposition. It is the valvular action of these folds that gives rise to the noisy respiration. The infants affected with this condition are as a rule otherwise healthy, and are apparently none the worse for their laryngeal deformity. The condition disappears within from a few months to two years.

Laryngeal Spasm in the Newborn.—G. F. Still calls attention to this condition which has also been described by Eustace Smith. Still reports the case of a female infant aged six days who had been having a number of attacks during the previous twelve hours. "The infant made violent inspiratory efforts without getting any air in, became more and more leaden-colored, bloody froth appeared at the mouth, and the child appeared to be dying of asphyxia. These attacks occurred sometimes without apparent cause, sometimes when the infant tried to take the breast." Nine attacks occurred within a few hours after Still saw the infant, who died apparently from exhaustion on the same day. Autopsy revealed nothing but a congestion of the pharynx and soft palate. Another case reported is that of a boy 7 1/2 weeks old who had had since birth sudden "crowing" attacks during which the infant became cyanosed. The attacks came on suddenly without apparent cause except possibly some digestive disturbance. When the diet was changed to peptonized milk no further attacks occurred. Eustace Smith found in three similar cases adenoid growths and postnasal catarrh, for mild cases of which he recommends the instillation of a weak solution of resorcin into the nostrils several times a day. During the attack the child's face or chest should be sprinkled with cold water, and smelling salts, a few drops of ether, or 1 minim of amyl nitrite may be held to the child's nostrils.

Chronic Laryngitis.—This condition in childhood may be caused by syphilis or by tuberculosis, but chiefly by the former. It gives rise to a gradually developing and persisting stridor, hoarseness, and loss of voice. There may be intercurrent attacks of laryngeal spasm, which then closely simulate attacks of catarrhal spasm, or of laryngeal diphtheria. The diagnosis is made with the aid of the laryngoscope or of direct laryngoscopy.

Stenosis of the Larynx.—This condition may be secondary to syphilitic or tuberculous ulceration of the larynx; to traumatism of this organ caused by a foreign body; or to the action of some caustic agent, as potassium hydroxide. The prolonged wearing of an intubation tube may cause ulceration of the larynx with subsequent cicatrization, and may also result in a considerable degree of adductor spasm. Hence following extubation a certain percentage of cases continue to manifest symptoms of laryngeal obstruction and spasm. These symptoms may be continuous, as evidenced by the laryngeal stridor and dyspnea, or may come on in attacks which closely resemble those of acute catarrhal spasm or of laryngeal diphtheria. Reintubation, tracheotomy, or an endolaryngeal surgical operation may be necessary to relieve an acute attack or to prevent its recurrence.

Reflex Spasm of the Larynx.—This is a rare cause of a form of croup which may closely resemble the other varieties. It may be caused by enlargement of the mediastinal lymph nodes, by cheesy degeneration in these nodes, by suppuration in the mediastinum, by acute pericarditis, or by acute pleurisy. There are more or less constant wheezing, an obstinate laryngeal cough strongly suggesting that of pertussis, and occasionally hoarseness. Treatment consists in the institution of those measures which serve to reduce glandular enlargments: residence at the seashore, and the administration of iodides, cod-liver oil, arsenic, calcium chloride (Goodhart), or sodium hyposulphite (Sturges).

Papilloma of the Larynx.—This condition is much more common in childhood than in adult life. The presence of the growth on a vocal cord may not give rise to any obstructive symptoms until it has at-

tained a certain size. The obstructive symptoms may start in suddenly, and may closely resemble those of an attack of catarrhal croup. Diagnosis of the real condition is impossible without the aid of the laryngoscope or of direct laryngoscopy. The following instructive case is reported by Still: "Eliza R., aged 3 1/2 years on March 4, began suddenly one night to make a stridulous noise with inspiration, and at the same time her voice became a hoarse whisper; these symptoms continued, and on April 22 she was brought to me as an out-patient at hospital, seeming quite well, with no discomfort, but still with marked stridor on inspiration and hoarse whispering speech. That same night she was suddenly seized with suffocative symptoms and died within a few minutes. Post-mortem, made by Dr. Hildesheim, showed a large papillomatous growth in the larynx."

Foreign Bodies in the Larynx or Trachea.—The inhalation of a foreign body may give rise to sudden symptoms of laryngeal obstruction, partly the result of the mechanical occlusion of the larynx, and partly the result of the adductor spasm and secondary swelling of the laryngeal structures induced by the foreign body. There may be inspiratory or both inspiratory and expiratory stridor, a persistent, ringing cough, dyspnea, cyanosis, and finally asphyxia and death. The diagnosis may be difficult if no history is obtainable. The foreign body may be felt with the finger. If the symptoms are urgent, and if inverting the patient and vigorously slapping him on the back do not succeed in dislodging the foreign body, it may be necessary to perform tracheotomy.

Retropharyngeal and Peritonsillar Abscess.—Retropharyngeal abscess is not uncommon in the first two years of life. Its presence may not be suspected in some instances until the swelling, which may be low down in the pharynx, presses upon the larynx and gives rise to sudden and pronounced symptoms of obstruction. The symptoms may closely resemble those of laryngeal diphtheria or of acute catarrhal spasm of the larynx. The diagnosis is made by feeling the bulging mass on the posterior or posterolateral wall of the pharynx. The treatment is incision of the mass and the evacuation of the pus. A peritonsillar abscess may point low down in the pharynx at the level of the larynx and may produce the same symptoms of obstruction as those caused by retropharyngeal abscess.

Edema of the Glottis.—In this condition there occurs suddenly or gradually a serous effusion into the mucous membrane covering the larynx, and chiefly into the aryteno-epiglottidean folds. Rounded, red, soft swellings are formed which may partly or completely occlude the rima glottidis. The condition is usually secondary to nephritis, but may be a manifestation of angioneurotic edema. The symptoms are pronounced inspiratory dyspnea and stridor with attacks of suffocation. Unless relieved the patient dies within a few hours. The diagnosis is made by feeling the grape-like masses surrounding the larynx. The treatment consists in scarification of these masses with a narrow-bladed curved knife, the application of ice to the neck, and having the patient swallow small pieces of ice. If the dyspnea is not relieved by these measures, tracheotomy is necessary.

Submucous Laryngitis.—This condition resembles edema of the glottis with the exceptlion that the cause is an inflammatory one. The epiglottis and all of the structures of the larynx are swollen and edematous. The causes are irritation by foreign bodies, the inhalation of steam or irritating gases, erysipelas of the neck, primary catarrhal laryngitis, or retropharyngeal abscess. The symptoms are the same as in edema of the glottis. In addition to the inspiratory difficulty, there are hoarseness, cough, pain, and dysphagia. The diagnosis may be made by means of the finger. The prognosis and treatment are the same as in edema of the glottis.

Bronchial Croup.—*Synonym:* fibrinous bronchitis. This may result from the extension of a diphtheritic membrane from the throat and trachea into the bronchial tubes or it may be a primary fibrinous inflammation of the latter. This condition may be acute or chronic, and is seen at all ages, but the severe form is more common in the young. The disease may be confined to some of the bronchial tubes, or it may affect all of them. The acute form differs from catarrhal bronchitis in the greater severity of the dyspnea and in the expectoration of tube casts from the bronchi. These casts show the characteristic tubular shape when examined in water. They are dissolved by lime water. The acute cases last from one to three weeks. According to Weil the mortality of these cases is 75 per cent. The chronic form of fibrinous bronchitis is characterized by the occurrence of repeated paroxysms of dyspnea and cough with the expectoration of fibrinous casts. There are no constitutional symptoms. The attacks occur every few days, or at intervals of weeks, months, or years. The prognosis in these cases is good. The treatment of both acute and chronic cases consists in the inhalation of the vapor of lime water, the internal administration of pilocarpine and expectorants, and sometimes of emetics. Potassium iodide is occasionally useful in the chronic cases.

Alexander Spingarn.

**Cruciferæ.**—(*The Mustard Family.*) A family of more than two hundred genera and probably fifteen hundred species, growing mostly in warm-temperate regions and widely distributed, many of them as common weeds. The family is of great economic importance, yielding the important food plants: cabbage, turnip, cauliflower, kale, sprouts, broccoli, and cresses of various sorts, and the important fixed oils of mustard, rape, and colza. The important medicinal constituents are a series of glucosides similar to sinigrin, which in decomposing yield volatile principles of which the volatile oil of mustard is the type, consisting of aromatic compounds similar to those of onion and garlic. The counterirritant and antiscorbutic properties of these oils will be described under *Sinapis* and *Cochlearia*. Quite a number of species, by virtue of these constituents, have been used as vulneraries. Such are the Shepherd's Purse (*Bursa bursa-pastoris* [L.] Britton), and various species of *Lepidium*, *Barbarea*, *Sisymbrium*, and *Brassica*. They apparently possess a germicidal and disinfectant power, and at the same time stimulate healing of the tissues. They are from time to time recommended as vulneraries for application to wounds and unhealthy ulcers.

Henry H. Rusby.

**Crum Mineral Springs.**—Mahoning County, Ohio.

Post-office.—Girard.

Access.—Electric railroad from Niles, Ohio, passes within about two miles of the springs. Fine macadamized roads pass the springs.

These springs are located about two miles from the city limits of Youngstown, Mahoning County; about a mile and a half from Mineral Ridge, Trumbull County; and about two and a half miles from the street cars of Niles, Ohio. No hotel has yet been built, but the water has been used commercially for the past twenty years. The surroundings are said to be very attractive and well adapted for a summer resort. The place affords telephone service and rural mail delivery.

The springs are four in number; only one, however, is in use. The following analysis was made by S. W. McKeown, analytical chemist:

| One United States Gallon Contains: | |
|---|---|
| Solids. | Grains. |
| Calcium carbonate | 5.31 |
| Magnesium carbonate | 1.80 |
| Iron carbonate | .59 |
| Sodium carbonate | .14 |
| Magnesium sulphate | 1.17 |
| Sodium sulphate | .48 |
| Silica | .29 |
| Total | 9.78 |

This analysis shows a combination of very useful ingredients. They give the water the properties of a ferruginous tonic, a mild diuretic, an antacid, and in large doses, a light laxative. The water is useful in disordered states of the stomach, kidney and bladder, and in functional affections of the liver and bowels. Its continuous use tends to overcome chronic constipation. EMMA E. WALKER.

**Crurin** is the trade name for bismuth-quinoline-sulphocyanate (or rhodonate). It is a reddish-yellow powder, insoluble in water, alcohol, or ether. It has been used as an antiseptic powder for dressing ulcers, chiefly syphilitic ulcers of the leg. As the use of the pure preparation is decidedly painful, it is well to dilute it with starch, using one part of crurin to one, two, three, or four of starch.

R. J. E. SCOTT.

**Cruveilhier, Jean.**—Born at Limoges, France, in 1791. He was educated at the University of Paris, and in 1825 he was made Professor of Anatomy in the same institution. In 1836 he became the first occupant of the recently established chair of pathological anatomy. He died at Jussac in 1874.

The titles of his more important published writings

FIG. 1622.—Jean Cruveilhier.

are as follows: "Anatomie descriptive," 1834–1836; "Anatomie pathologique du corps humain," 1829–1842; "Traité d'anatomie pathologique générale," 1849-1864; "Anatomie du système nerveux de l'homme," 1845; and "Traité d'anatomie descriptive," 1851. A. H. B.

**Crying** is an involuntary disturbance of respiration accompanied by relaxation of the facial and jaw muscles and lacrymation; it is usually an expression of strong emotion, such as grief, fear, anger, or pain. The inspiration is short and deep, sometimes spasmodic in character; the expiration is prolonged; the glottis is narrowed and an inarticulate sound is usually produced. The eyes are generally closed, and the angles of the mouth are depressed.

Crying is the only language of the new-born babe, its only means of expressing its desires, discomfort, or dissatisfaction with its surroundings. The first welcome cry expands the lungs and probably assists in establishing the normal course of the circulation. The lustiness of it is taken as a measure of the infant's vigor. The cry of the infant differs, however, to some extent from that of the adult, in the facial expression, in the absence of tears, and in the sound produced. The eyes are closed, the mouth is widely opened, the chin often quivers. With the development of the lacrymal and salivary glands, however, we have, by the third or fourth month, a flow of tears and often drivelling.

*Physiology.*—In crying the diaphragm is suddenly deeply depressed, causing full inspiration. The action is involuntary and is so quick that the other respiratory muscles probably take little or no part in it. The ascent of the diaphragm may be uniform or interrupted, and the air is forced through a partially closed glottis, producing a steady or a broken, inarticulate sound, varying, as a rule, with the character of the lamentation. The inspiration is sometimes also intonated (the "reprise"). The contraction of the laryngeal muscles sometimes becomes clonic and painful in the prolonged crying of deep distress. The circulation is accelerated; the face and even the entire integument of the young infant may become engorged with blood. Although the act is involuntary, it may be closely simulated, and it may be voluntarily arrested. The nervous mechanism of crying is not fully understood. It is closely related to that of laughing, so closely, in fact, that in children and hysterical adults either may quickly give place to the other. Crying may be inaudible when, from embarrassed respiration as in the weakness of marasmus, syphilis, rachitis, or pneumonia, the infant cannot produce the sound, or when, on account of pain, it suppresses it, as in pleurisy. The deepest grief is often expressed in silence, the face buried in the hands, perhaps, while the tears refuse to flow. Tearless crying in an infant more than four months old is regarded as an unfavorable symptom.

*Significance of Crying.*—Much may be learned of an infant's condition by observing its expression and its actions while crying, as well as from the character of the act itself, but it is going a step too far to say that the location of the disease can always be determined from the cry. Persistent crying always indicates the existence of something abnormal. It may denote hunger, as the mother is apt to believe; it is probably just as often a sign of thirst. If, however, the infant refuses to take the breast, this element is ruled out, providing there be no other cause for refusal, such as obstruction of the nostrils or disease of the mouth or throat. The cry of hunger is fretful, and is generally interrupted by vigorous sucking of the fingers or hunting for the breast, but the discomfort induced by overfeeding is manifested in the same manner. Nursing relieves hunger, but stops the cry of overfeeding only for the moment. In pain about the head the brows are generally knit and the hands are often raised to the region of the pain. In earache the cry is most persistent, and the hands may be held to the side of the head or thrust into the mouth, as is often the case also in disease of the mouth or throat. The sudden, sharp, hydrocephalic cry is characteristic of cerebral disease, but only in the presence of other symptoms. In painful diseases of the chest the cry is not loud, as a rule; it is more frequently moaning in character, or each expiration may be slightly intonated. When coughing is accompanied or followed by crying it arouses suspicion that the bronchitis has reached the smaller tubes and that catarrhal pneumonia is imminent. The absence of crying is often of greater significance. The cry of weakness is low in tone, and has more the character of whining or moaning; it is often indicative of marasmus, atelectasis, or of

hereditary syphilis when it has also a nasal tone. A hoarse cry denotes a catarrhal condition of the larynx which may be due to "cold," syphilis, diphtheria, or pseudocroup. The "croupy" cry, with corresponding cough, signifies a dry or inflamed condition of the vocal cords or a spasmodic closure of the glottis as in laryngismus stridulus. In abdominal pain the crying is usually accompanied by squirming movements of the body and by drawing up of the legs or kicking. It ceases with the evacuation of the bowels in catarrh of the small intestine, but accompanies and follows it in colitis or dysentery. Laying the infant upon its abdomen stops it, not by relieving the pain, but by so impeding the respiration that it cannot cry. When continuous crying is unaccompanied by other symptoms of illness, errors may often be avoided by the removal of all clothing in order to exclude such causes as the pricking of a pin, inflammation about the umbilicus, or a recently developed hernia, dislocation, or fracture. The infant with rheumatism or pleurisy, and not infrequently the rachitic child, cries with pain when it is picked up; pressure upon different regions in succession will generally locate the tenderness.

In older children the manner of crying is often an index to the emotion expressed. In the cry of fear, for example, the eyes remain open and the orbits are turned toward the source of danger; the lips and often the entire face become pale; the outcry is short and loud. The cry of anger is also loud, but the lower lip protrudes in a pout, and the face becomes livid. The peevish cry of the spoiled child is accompanied by peeping eyes, a scarcity of tears, and whining often breaking into a staccato movement. The cry of pain corresponds to the character of the pain and varies from a sudden violent scream to a whine more like that of peevishness. In anger or pain the breath is often held until the face becomes cyanotic and the veins become distended. Convulsions have followed such paroxysms, and death has been attributed to them in a few instances. Such results would probably more frequently follow were it not for the anatomical peculiarities of the infant's circulation which permit the distention of superficial vessels and the more rapid flow of venous blood from the cranium. Finally, crying often becomes a habit with overindulged children. Even young infants learn it and cry not merely for food or drink, but to be carried, to be rocked, for the light, or apparently for no other purpose than to attract attention. It is easily cured by persistent and total disregard of it on the part of the nurse.

Crying has also its significance in the adult, but much depends upon the emotional nature of the individual. Some persons maintain a stoical indifference to the most trying circumstances, while others are moved to tears by the merest trifles. The latter class are especially susceptible to the influence of suggestion. Crying frequently occurs in intoxication by alcohol and other stimulants, especially in advanced dipsomania. In the morphine habitué, when frequent it is sometimes indicative of the approach of imbecility. The weeping of the hysterical woman is characteristic in the depth of grief expressed, in the violence of the outcry, or its dramatic pathos, and especially in its sudden change to an equally violent fit of laughter. Crying is often a symptom of neurasthenia. In paralytic dementia and other forms of emotional insanity a tendency to weep is sometimes one of the earliest symptoms, and in the closing period of the disease it may often be induced by the most trivial circumstances, the asking of a question, or a mere glance at the patient. Many other diseases not necessarily involving the mind are attended by so great depression of spirit as to render weeping of frequent occurrence. Not infrequently, however, temporary improvement seems to follow a good fit of crying just as it often follows hearty laughter.

JAMES M. FRENCH.

**Cryoscopy.**—This term (from κρύος cold, σκοπέω, I examine) is applied to the determination of the freezing-point of a fluid.

The freezing-point of all fluids is dependent on the amount of substance or substances in solution. Thus the freezing-point of absolutely pure water is 0° C., that of distilled water is near this point. Dissolving a substance in water increases the freezing-point depression to a degree directly proportional to the number of molecules in solution, if the substance is one whose molecules do not dissociate. If the substance is one whose molecules or some of whose molecules dissociate into ions on solution, the depression of the freezing-point will depend on the number of intact molecules plus dissociated molecules or ions. Each ion has the depressing power of a molecule.

Theoretically all normal, or gram-molecular[1] solutions, having the same molecular concentration should give exactly the same depression of the freezing-point (−1.85° C.). Because of dissociation, however, this does not hold true for all substances. Thus a normal solution of sodium chloride depresses the freezing-point −3.51° C. because many of the molecules are present not as NaCl molecules but as Na and Cl ions, each having the depressing power of a molecule. The amount of the dissociation bears a relation to the dilution, it being greater the greater the dilution; therefore the more dilute a solution the greater the relative freezing-point depression.

In a simple solution, knowing the theoretical depression, it is possible to determine by cryoscopy the number of molecules present as such and those present as ions. For example the gram-molecular solution of NaCl depressing the freezing-point as we have seen −3.51° C. instead of −1.85° C. corresponds in concentration to an undissociated solution containing $\frac{3.51}{1.85}$ or 1.89 gram-molecules. Therefore, the number of molecules plus ions is equivalent to the theoretical number times 1.89. From these numbers, which will vary in different dilutions, may be determined the amount of substance ionized.

Formula: X = ionized portion.

$$X = \frac{\frac{\text{F. P. found}}{\text{F. P. calculated}} - 1}{\text{number of ions in one mol.} - 1}$$

*i.e.* for NaCl: $X = \frac{\frac{3.51}{1.85} - 1}{2 - 1}$ or $\frac{1.89 - 1}{2 - 1} = 0.89$. Therefore eighty-nine per cent. have been ionized and eleven per cent. exist as molecules.

Unfortunately complex solutions of varying composition such as the body fluids do not permit the application of these calculations. In such solutions the total depression of the freezing-point is equal to the sum of the depressions due to the various substances in solution. In this regard it will be seen that the freezing-point resembles the osmotic pressure in which the total pressure of a complex solution is the sum of the pressures exercised as partial pressures by the various substances in solution. The freezing-point is therefore a measure of the osmotic pressure to which it is proportional. The freezing-point, on the other hand, differs from the specific gravity in being influenced not by the size and weight of the molecules but by their number. For this reason the influence of albumin on the freezing-point is slight, its molecules being very large and few in number.

From the preceding remarks on the principles involved the difficulties of interpreting cryoscopic findings in a complex body such as the urine will be appreciated.

The normal depression of the freezing-point of the urine (indicated by the symbol Δ) varies between

[1] A gram-molecule is the molecular weight of a substance expressed in grams.

−0.8° and −2.47° C., that of the blood (indicated by the symbol $\delta$), which is much more constant, between −0.56° and −0.58° C. To make the observations of any value examination must be made of both fluids specimens of which should be taken at the same time. Subsequent examinations should be made under similar conditions. Even when these precautions are taken the results cannot be interpreted dogmatically. Theoretically in pre-uremia uremia, and some forms of nephritis the concentration of the blood should be increased and that of the urine diminished. This should result in an increased $\delta$ to −0.60 and a fall of the $\Delta$ to a point which may equal or exceed that of the blood. These findings would suggest the impermeability of the kidneys for dissolved substances. They may, however, be due entirely to the increased output of water just as on the other hand an increased water retention (as in nephritis with edema) will cause a diminution in the $\delta$ because of dilution while the urine because of concentration shows an increased depression.

Records are available of cases of uremia in which the cryoscopic findings were normal, and on the other hand are records of cases with abnormal findings and no demonstrable pathological lesions of the kidneys at autopsy. This might be explained by the taking up of osmotic regulation by some other organ or tissue.

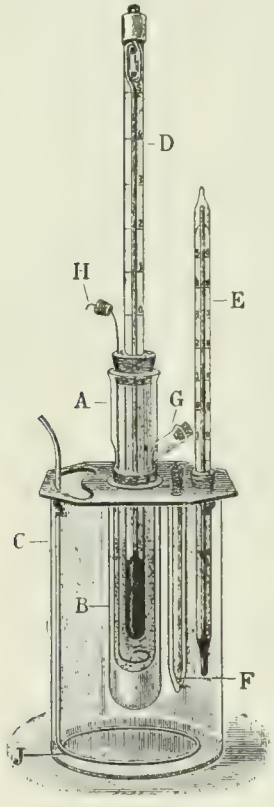

Fig. 1623.—Beckmann's Cryoscopy Apparatus.

An attempt has been made to standardize the results of urine examinations by the employment of a valence number and through this expressing the depressing factors in terms of chlorides and achlorides. This number is obtained by multiplying the $\Delta$ by the total volume for twenty-four hours. If one divides this number by 61.3 one obtains the amount of pure NaCl necessary to give the same depression. If from this result is deducted the amount of NaCl actually present (determined chemically), one obtains the NaCl equivalent of the achlorides present. To overcome the variations due to different concentrations specimens should be diluted ten or twenty times.

The comparison of the molecular concentration of catheterized ureteral specimens is sometimes valuable. Only well-marked differences are significant, however, and it is not safe to base conclusions as to the functional efficiency of a kidney on this procedure.

Application of cryoscopy to the study of other body fluids as transudates, exudates, gastric juice, and saliva have yielded no useful clinical results. It was hoped that the determination of the molecular concentration of transudates and exudates as compared with that of the blood would help in determining the probability of resorption, but the result is frequently the opposite from that which one would be led to expect. Indeed it is not possible to differentiate transudates from exudates by this method. This will be understood when the small influence of albumin on the freezing-point is recalled.

The apparatus for the determination of the freezing-point best suited to the clinical laboratory is that devised by Beckman. (Fig. 1623.)

It consists of an outer jar C with cover and stirring rod J. The cover has a hole at one side for the passage of the stirring rod and a second hole in the center through which passes and the edges of which support a large test-tube B which contains a perforated cork. This cork supports a second test-tube A which fits within B and is separated from it by an air space. Test-tube A is closed by a perforated cork through which passes a thermometer D of a special type and a small stirring rod or wire H. The thermometer has an arbitrary scale of six degrees, each degree being subdivided into 0.01° C. There is a reservoir at the upper end for the mercury and the amount leaving this reservoir is easily regulated.

In all examinations a preliminary blank test must be made with distilled water to determine the zero point for the conditions obtaining at that particular time.

The procedure is as follows: A mixture of ice and salt is placed in the outer jar C and the fluid to be examined in the tube A. The fluid in A may be cooled by placing it directly in the ice and salt mixture until near 0° C., as indicated by an extra thermometer. Tube A is then quickly placed in tube B and the special thermometer introduced. The temperature is reduced by stirring the freezing mixture and the fluid in A is kept agitated by stirring wire H. As the freezing-point is approached the mercury leaves the reservoir and runs down the scale. It at first sinks to a point below the freezing-point but quickly rises owing to the liberation of heat at the moment of freezing and remains stationary for a short time. It is at this point that the reading is to be made. In the case of distilled water this point will not be necessarily zero as it is dependent on the amount of mercury leaving the reservoir. It is, however, the actual zero for distilled water under the conditions then obtaining. Should this point be so high that the freezing-point of the fluid under examination will not come within the limit of the scale the tests of both fluids must be repeated after shaking some of the mercury back into the reservoir. The difference between the reading for distilled water and that for the fluid under investigation is called the freezing-point depression.

Joseph C. Roper.

**Cryptocystes.**—Microsporida, a suborder of *Myxosporida* which commonly infests invertebrate hosts, especially arthropods. These parasites are more effective than any other group of *Sporozoa* in impairing the health and vitality and often cause epidemics. Such epidemics have been recorded among fish, silk-worms, crayfishes, and other animals. See *Protozoa*. A. S. P.

**Crystalloids** may be defined as those substances which are capable of passing through a membrane. The term crystalloid originated with Graham, and is opposed to the term colloid under which are included all those substances that do not possess the property of passing through a membrane. The crystalloids are as a rule crystalline bodies, a fact which with a few exceptions does not apply to the colloids.

Frank P. Underhill.

**Ctenocephalus.**—A genus of fleas, *Pulicidæ*, found on rats, mice, dogs, cats, and other animals, which act as secondary hosts for immature stages of tapeworms. This genus has ctenidia on both the head and prothorax. See *Insects, parasitic*. A. S. P.

**Ctenopsylla.**—A genus of fleas, family *Pulicidæ*, found as parasites on rats and mice. See *Insects, parasitic*. A. S. P.

**Cuba.**—The island of Cuba, which was discovered by Columbus, lies between 74° and 84° of west longitude and 19° and 23° north latitude. It is long and narrow, of an average breadth of about 66 miles and of a length of 640 miles. The area, including the adjacent keys and islands, is estimated at 45,000 miles, a little less than the State of New York.

The coast is very extensive and surrounded by numerous small islands and keys, and in most places rises abruptly from the sea. There are a number of good harbors, Santiago de Cuba, Havana, Matanzas, Cardenas and Cienfuegos being the principal ones.

A range of mountains, known as the Sierra Maestra, borders the southeast coast from Cape Maisi to Cape Cruz. The highest peak of this range and the highest point in the island is Pico de Turquino, 7,670 feet. From this range there extends very nearly through the center of the island a general ridge or range of hills of more or less elevation. The island is divided by this ridge into two general watersheds, one draining toward the north and the other toward the south.

About one-fourth of the total area is estimated as mountainous, three-fifths as rolling plains, valleys, and arable slopes, and the remainder swamps. Humboldt describes the interior of the island as gently undulating, like that of England, and not more than 280 to 380 feet above the level of the sea.

The rivers are numerous but short.

A variety of minerals are found, among the chief of which are iron and copper, which are mined and exported. There are also coal of good quality and petroleum.

In various parts of the island are mineral springs of local repute, those of San Diego in Pinar del Rio and of Madruga, southwest of Matanzas, are the most frequented; the latter contains iron, sulphur, magnesia, and potash.

*Flora.*—The flora of Cuba is rich and very varied and the soil is fertile. There are large areas of primeval forests; and trees of many kinds furnish cabinet and building wood of beauty and excellence, such as mahogany, ebony, the Spanish elm, cedar, oak, pine and palm, of which there are more than thirty species. From some trees various dyes are obtained, such as logwood and indigo. Others are rich in gums, resins, and oils, while still others furnish medicinal substances. There are a large number of edible plants and a variety of delicious fruits common to the tropics, as the pineapple, tamarind, banana, orange, pomegranate, and mangoe. Sugar and tobacco are the two agricultural staples, while maize, rice, sweet potatoes, coffee, and cocoa are extensively cultivated. Cattle raising is also extensively carried on.

*Fauna.*—There are no large animals, and of indigenous mammals the agouti, about the size of a rabbit, is plentiful. Another peculiar animal is the solenodon. There are no venomous reptiles. Birds are very numerous, and there are said to be more than 200 indigenous species, of which the parrot and mocking bird are the best known, the latter noted for its song. Fish abound, but edible ones are not abundant. Oysters and shellfish are plentiful, but the quality is inferior.

*Climate.*—The climate of Cuba, like that of all tropical islands, is characterized by warmth, equability, humidity, and abundant rainfall. From its situation in the north tropical zone, it comes within the region of the northeast trade winds, which blow steadily throughout the year. As in other tropical regions, there are two seasons: the dry and cooler one, from November to April; and the wet and warmer one, from May to October.

As is the case with all the West Indian Islands, hurricanes, often of very destructive violence, are more or less frequent, and are most likely to occur in the months of October and November.

Climatic conditions vary somewhat in different portions of the island, depending upon differences in latitude, geographical position, and topography. The interior is somewhat cooler than the coast and in the highlands frost is said to be not uncommon. The southern coast, except in sheltered localities, is also somewhat cooler than the northern. The trade winds and the afternoon sea-breezes render the heat less oppressive.

The meteorological statistics are comparatively few and fragmentary, those at Havana being more extensive than elsewhere. The following table, arranged from data obtained from the U. S. Weather Bureau, indicates the various climatic characteristics as observed at Havana, and will therefore stand in a general way for those of the whole island, though at other points of the island the figures vary within small limits depending upon the locality and altitude. Thus, at Matanzas, on the coast, fifty miles east of Havana, the mean temperature for two years was 78° Fahr.; at Santiago, the average temperature is about 80° Fahr.; at Cienfuegos, the average temperature for eleven months was 76° Fahr.; at the San Fernando Mines, at an elevation of 554 feet above sea-level, the average temperature for one year was 75° Fahr., the highest and lowest being 98° Fahr. and 51° Fahr., respectively. Humboldt states that he was credibly informed that in the country near Havana on a hill 318 feet above sea-level, water had frozen and thin ice formed.

CLIMATE OF HAVANA, CUBA, LATITUDE 23° 9′ N.; LONGITUDE 82° 23′ W.; ELEVATION 63 FEET.

(Reports Bellen College, Ten Years, and Others.)

| | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Temperature (Degrees F.).* | | | | | | | | | | | | | |
| Average or normal | 70.3° | 72.0° | 73.2° | 76.0° | 78.8° | 81.5° | 82.4° | 82.2° | 80.7° | 78.1° | 75.3° | 71.4° | 76.8° |
| Mean of warmest | 81.8° | 85.8° | 88.9° | 93.3° | 94.0° | 95.3° | 95.2° | 93.8° | 92.1° | 89.0° | 85.7° | 82.3° | 89.7° |
| Mean of coldest | 56.6° | 57.5° | 58.7° | 62.1° | 66.8° | 71.6° | 72.5° | 72.1° | 72.4° | 67.8° | 65.5° | 57.9° | 65.1° |
| Average daily range | At Havana the average is perhaps a little more than 10.0° | | | | | | | | | | | | |
| Highest or maximum | 84.4° | 87.6° | 91.4° | 93.6° | 99.0° | 97.7° | 100.6° | 98.6° | 94.1° | 91.9° | 88.7° | 86.0° | 100.6° |
| Lowest or minimum | 52.3° | 49.6° | 55.0° | 60.4° | 64.4° | 69.1° | 71.2° | 69.8° | 70.9° | 61.7° | 56.5° | 51.8° | 49.6° |
| *Humidity.* | | | | | | | | | | | | | |
| Average relative | 78.6% | 78.3% | 73.0% | 78.6% | 78.3% | 80.0% | 77.6% | 77.0% | 81.6% | 80.3% | 78.6% | 74.3% | 77.1% |
| *Precipitation.* | | | | | | | | | | | | | |
| Average in inches | 2.71 | 2.27 | 1.83 | 2.83 | 4.47 | 7.16 | 5.06 | 6.02 | 6.71 | 7.42 | 3.08 | 2.15 | 51.73 |
| *Wind.* | | | | | | | | | | | | | |
| Prevailing direction | The prevailing winds are from the E. and N.E. | | | | | | | | | | | | |
| Average hourly velocity in miles | Winter months, av. velocity 8.5; Summer months 6.5 | | | | | | | | | | | | 7.5 |
| *Weather.* | | | | | | | | | | | | | |
| No. of days upon which rain fell | 7.5 | 5.7 | 5.5 | 4.6 | 9.3 | 12.8 | 12.7 | 12.6 | 15.4 | 15.1 | 10.2 | 8.5 | 119.9 |

The following table, compiled by Phillips in the article upon Cuba in the previous edition of the HANDBOOK, gives the average summer and winter temperatures at several stations in Cuba, and the same, for comparison, of several places in the West Indies and elsewhere.

| Stations. | Summer. | Winter. |
|---|---|---|
| Havana (10 years) | 82.0° | 71.2° |
| Uhajay (4 years) | 83.1° | 65.0° |
| San Fernando Mines (one year) | 79.7° | 69.7° |
| Firmeza (10 years) | 81.4° | 75.9° |
| Santiago (4 years) | 83.4° | 77.8° |
| Key West, Fla. (21 years) | 83.8° | 71.1° |
| San Juan, Porto Rico (12 years) | 81.3° | 76.3° |
| Kingston, Jamaica (10 years) | 80.8° | 75.0° |
| Praia, Cape Verde Islands (5 years) | 78.1° | 73.1° |
| Honolulu, Hawaii (7 years) | 77.2° | 70.6° |
| Manila, Philippines (17 years) | 81.3° | 77.3° |
| New Orleans, La. (28 years) | 81.3° | 55.8° |
| Galveston, Texas (18 years) | 83.3° | 55.6° |
| Washington, D. C. (24 years) | 74.9° | 35.1° |

San Juan, Kingston, Praia, Honolulu, and Manila are situated within or not far from the same latitudes as the Cuban stations. The maximum temperature of the day at Havana occurs usually between twelve and two o'clock and the minimum between dawn and sunrise. The average relative humidity, as will be seen, varies but little from month to month, but the diurnal range is considerable, varying from eighty-eight per cent. in the morning to sixty-four per cent. at noon.

*Rainfall.*—As will be seen from the table, the greatest amount of rainfall occurs in October and the next greatest in June. In the period from June to October occurs sixty-three per cent. of the annual rainfall. Although, as will be seen from the table, the average number of days of rainfall at Havana for the period of observation was 119.9, or nearly one day out of three, it must be remembered that the days on which rain falls are not continuously cloudy. Tropical rains are heavy but not of long duration, and as soon as the rain ceases the clouds break away and the sun appears. In the majority of cases rain falls before the middle of the day. One should not forget that the division of the seasons of Cuba into "rainy" and "dry" is but a relative one. More rain, for instance, falls at Havana during the dry season than at Denver or Los Angeles during the whole year.

Although the average number of clear, cloudy, and partly cloudy days are not at hand for Havana, those at San Juan, Porto Rico, which does not differ very greatly in latitude, were for a period of five years as follows:

SAN JUAN, PORTO RICO, LATITUDE 19° 27′ N. LONGITUDE 66° 7′ W.

| Year. | Clear days. | Partly cloudy. | Cloudy. |
|---|---|---|---|
| 1906 | 150.0 | 126.0 | 89.0 |
| 1907 | 180.0 | 126.0 | 59.0 |
| 1908 | 158.0 | 137.0 | 71.0 |
| 1909 | 173.0 | 121.0 | 71.0 |
| 1910 | 188.0 | 103.0 | 74.0 |
| Average, 5 years. | 169.8 | 122.6 | 72.8 |

The following table shows the average amount of rain falling in the "wet" and "dry" seasons at some of the stations mentioned in the previous table, with one or two others.

| Stations. | Wet May to Oct. | Dry Nov. to April. |
|---|---|---|
| Havana[1] (30 years) | 32.37 | 19.36 |
| Matanzas (one year) | 44.01 | 11.28 |
| Santiago (one year) | 24.31 | 9.51 |
| Firmeza (10 years) | 47.78 | 13.97 |
| Port au Prince, Hayti (4 years) | 39.05 | 22.12 |
| San Juan, Porto Rico (12 years) | 35.83 | 25.38 |
| Kingston, Jamaica (10 years) | 26.03 | 6.61 |
| Key West, Florida (25 years) | 29.50 | 10.60 |
| Honolulu, Hawaii (16 years) | 14.65 | 24.89 |
| Manila, Philippines (32 years) | 55.04 | 20.39 |
| New Orleans, La. (25 years) | 27.00 | 33.53 |
| Washington, D. C. (25 years) | 24.10 | 20.60 |

[1] Rainy season, June to October; dry, November to May.

*Winds.*—The prevailing winds are the "northeast trades," the average velocity at Havana being about 7.5 miles an hour. These winds wax and wane during the day, beginning with a velocity of four miles an hour at about 4 A. M., and increasing as the day advances until a velocity of eleven miles is reached at 2 P. M., and then diminishing gradually to a velocity of four miles again. These winds blowing with such constancy mitigate greatly the effect of the heat and humidity and are a source of comfort and health. "In the winter season," says Phillips, "cold waves from the United States when extending far to the southward cause cold northerly winds or 'northers' along the north Cuban coast."

*Storms.*—Thunder storms occur frequently, especially so during the summer, generally in the afternoon; they do, however, very little damage. The hurricanes, before mentioned, occasionally visit Cuba, in common with the other islands of the West Indies; but their destructive path is limited to a relatively narrow region.

*Health.*—Previous to and during the Spanish War, the mortality in Cuba was very high, reaching to nearly 40 per 1,000, the principal diseases being tuberculosis, intestinal affections, smallpox, and fevers, especially yellow fever, which was endemic in Havana and most of the other seaports. During the occupancy of Cuba by the United States Army, under the wise administration of Gen. Wood, the sanitary condition of Havana and other places was greatly improved, and this has been continued under the republic. It was not, however, until the brilliant and fearless investigation of Dr. Walter Reed and his associates, Drs. Carroll, Agramonte, and Lazear, the latter sacrificing his life to the cause, proved that the true source of infection was the mosquito of the species known as stegomyia, that yellow fever began to be eradicated by the destruction of this insect, or protection from it. At the present time yellow fever is practically banished and is no longer a menace. Large amounts of money have been spent in sanitary improvements in Havana and elsewhere, and this, together with the extinction of yellow fever, has decreased the death rate almost if not quite one-half. Smallpox, which was said to be the cause of a greater mortality than yellow fever even, has also been controlled by vaccination. There is, however, a very high death rate from tuberculosis, as is the case of many other tropical regions, due to the unhygienic condition under which many of the inhabitants live; they sleep in closed rooms at night, eat unwholesome and insufficient food, and are generally irregular and unclean in their mode of life. It has been shown that three-fourths of Havana's population live, or did live, in the most densely populated locality in the world. Leprosy is not uncommon in this island.

*Population.*—The census of 1907, the last one taken, showed the total population to be 2,048,980. Of this number native whites constitute 58.8 per cent.;

negroes and those of mixed blood, 29.7 per cent.; foreign-born whites, 9.9 per cent.; Chinese less than 0.6 per cent. These proportions vary, however, in different portions of the island; in the province of Oriente, for example, 43.1 per cent. of the population are negroes. There is no color distinction in Cuba, either politically or socially. Here the colored man stands on an equality with the white man and enjoys an equal opportunity for development.

The religion is overwhelmingly Roman Catholic, but the Church and State are separate. Illegitimacy is high and there are many unions without sanction of Church or State.

Cuba is readily reached by various steamship lines from New York, New Orleans, Mobile, Tampa, and other ports. By the completion of the East Coast Florida Railroad one can reach Key West by rail, whence there is a sea voyage of only about eight and a half hours to Havana.

Certain precautions are wise for one visiting the island, and these apply as well for other tropical countries.

One should be sure that the drinking water is from a pure source, or, failing this, the water should be boiled. The food should be of good quality and properly prepared. As a rule, some loss of appetite is experienced and only a moderate amount of food should be taken. Stimulants are best avoided. The clothing should be loose, of cotton or linen, and Phillips advises the wearing of a bandage of gauze or other light material at night to lessen the likelihood of undue cooling from nocturnal radiation which is relatively very great in tropical latitudes; for the same reason one should sleep indoors. A mosquito-net should always be used either in the windows or about the bed. Exercise, which should be very moderate, is best taken in the cooler part of the day before 10 A. M. and after 3 P. M. When exposed to the sun, an umbrella is desirable. Wet clothing should be changed for dry as soon as possible. EDWARD O. OTIS.

**Cubeb.**—CUBEBA. "Cubebs." "The dried, unripe, but fully grown fruit of *Piper cubeba* L. (fam. *Piperaceæ*)" (U. S. P.).

This species is a climbing plant with perennial, smooth, flexuous, branched stems, and alternate lanceolate, bright green, and shining leaves. The flowers are dicœcious and aggregated in close linear catkin-like spikes. Native of Java, Sumatra, Borneo; also cultivated in the coffee plantations of Java and Sumatra, as well as in the West Indies. The drug generally reaches us through the commercial ports of India. It has been known in Europe since the Middle Ages, having been introduced through the Arabian physicians, and its earliest employment appears to have been as a spice. It was, however, used in genito-urinary troubles by the Arabians centuries ago; but that employment either never took any hold in European medical practice or completely died out long ago, and was not revived until the beginning of the present century, when it was reintroduced by medical officers stationed in India.

Cubeb consists of the whole fruits dried. They are about five millimeters (¼ in.) in diameter, globular, wrinkled by the shrinking of the juicy mesocarp, slightly pointed at the apex, sometimes flattened at the base, from which the slender brittle stalks, in reality the narrowed portion of the fruit, project from two to six millimeters. They each contain a roundish stone within which is a single flattish seed, or, as the fruits are collected before maturity, frequently an air space. Color, grayish-brown, or blackish; odor, strongly aromatic and peculiar; taste, spicy, but milder than that of pepper.

Cubeb has been the subject of very extensive adulteration, and the adulterants have been numerous, chiefly the fruits of other species of Piper. They are to be distinguished chiefly by the characters of the stalk and the taste. The stem (rachis) of the cluster, which is to be sifted out, is also extensively sold for cubeb, in the ground state.

Cubeb contains from six to twelve or more per cent. of a composite *essential oil*, which is official (*Oleum Cubebæ*, U. S. P.), also about three per cent. of an amorphous resin, nearly an equal amount of *cubebic acid*, and *cubebin*, besides some fat and other uninteresting ingredients. Cubebin is bitter, but nearly inert. The resin and cubebic acid are active, but the value of the drug depends chiefly upon the oil, which is considered below. All the above substances combined, extracted by ether and concentrated by evaporating the solvent, compose the so-called "Oleoresin of Cubeb" (*Oleoresina Cubebæ*, U. S. P.), of which the yield is from sixteen to twenty per cent. of the cubeb.

ACTION AND USE.—Cubeb is mainly an aromatic spice, like its near relative, pepper. The odor and flavor are due to its oil, the pungent taste to its amorphous resin. As a local stimulant to digestion, as an ingredient of cough mixtures and gargles, it has a certain value which it shares with others of its class. But nearly all the call for cubeb is in diseases of the bladder and urethra, especially in gonorrhea and gleet. It is eliminated by the kidneys, whose secretion it augments slightly and scents decidedly, and the urine so impregnated soothes the bladder and urethra, through which it passes, and diminishes the formation of pus—by exactly what process cannot be said.

The drug is distinctly inferior to copaiba, for the same purpose.

Its irritating effect upon the stomach is apt to be reflected upon the skin by an erythematous eruption, which, however, cannot be regarded as characteristic of this drug.

ADMINISTRATION.—It may be given in powder, the dose of which is from ʒi.–iii. (4.0–12.0); the bulk is generally an objection. There is official, besides the oleoresin, a fluid extract which may be reduced, if desired, by syrup or mucilage. The twenty per cent. tincture, no longer official, is an excellent preparation. The oleoresin represents about six times its weight of cubeb. From the oleoresin are made the troches of cubeb, each containing 0.04 gm. (about gr. ss.), considerably used as a popular "expectorant" in pharyngitis, etc.

OLEUM CUBEBÆ.—The source of this oil is explained above. It varies from colorless to greenish or yellowish, has a specific gravity of 0.905 to 0.925 at 25° C. (77° F.) and dissolves in an equal volume of alcohol. It has the characteristic odor of cubeb. It consists chiefly of cadinene ($C_{15}H_{24}$), apparently identical with the active portion of oil of copaiba. Upon keeping the oil, a portion of it becomes converted into cubeb camphor ($C_{15}H_{24}.H_2O$). The same change occurs in it in the fruit if the latter becomes old, and this product will be contained in the oil distilled from such fruit. Oil of cubeb has the same properties as cubeb, and is given for the same purposes, in doses of ♏v. to xv. (0.3–1.0). HENRY H. RUSBY.

**Cucumber.**—See *Cucurbitaceæ*.

**Cucurbitaceæ.**—(The Cucumber or Gourd Family.) A family of some ninety genera and more than five hundred species, of great economic interest, both generally and medicinally. The plants are perennial, tendril-bearing herbs or undershrubs, rarely shrubs, and either prostrate or climbing. They inhabit warm, and especially tropical regions, throughout the globe. They are of rather delicate vitality and easily destroyed by accident, yet they are very commonly inhabitants of sandy, arid regions, and the family is noted for its protective provisions. Most common among these are purgative or poisonous con-

stituents. These are very commonly stored in large fleshy and starchy roots, like the bryony, many of which have to endure long periods of rest, subject to decay, against which they can be protected by resins, and to attacks by foraging animals, against which they are protected by poisonous glucosides. The pulpy fruits, like those of colocynth and elaterium, are often similarly protected. The seeds are very commonly anthelmintic and diuretic. Besides the well-known drugs colocynth, elaterium, bryony, and pumpkin seed, separately considered, a very large number are used locally, or in domestic practice, for the same purposes. Among such seeds may be mentioned those of squash, cucumber, and melon; among roots, various species of Wilbrandia, Megarhiza, Cayaponia, Corollocarpus, Kedrostis, Modecca, Melothria, and Lagenaria; among fruits, species of Luffa, Momordica, and Trichosanthus, besides those of some of the above-mentioned genera. The use of the bland pulps of some of these fruits, such as cucumber, for poultices, is to be regarded as chiefly, if not wholly, mechanical. The juice of the stems and fruits frequently carries the drastic principle. Upon the other hand, many of our most useful vegetables are derived from these fruits, as the melons, pumpkins, squashes, cucumbers, citron melons, cayotes, calabashes, and acchocte.

HENRY H. RUSBY.

**Cudbear.**—See *Persio*.

**Cullen, William.**—Born December 11, 1712, in Scotland. After serving a short apprenticeship, with a surgeon and apothecary in Glasgow, he secured the position of surgeon on a merchantman bound for the East Indies. Not liking this kind of life, however, he returned to Scotland and began the practice of medicine, first in a small village and then afterward in Hamilton. He made the acquaintance, at about this time, of William Hunter. Both of these young men were anxious to secure the benefit of lectures at the University, and yet neither of them was able to afford the expense. They therefore entered into an agreement that, while one of them was at the University, the other should remain at his practice and earn, if possible, enough money for both of them. It was in this way that Cullen found it practicable to attend lectures at the University of Edinburgh and to obtain the degree of Doctor of Medicine (in 1740). The Duke of Argyle and the Duke of Hamilton, to both of whom he had rendered some small service, were able to advance him materially in his career. It was upon the latter's recommendation that he received his appointment to the chair of chemistry in the University of Glasgow. The brilliant manner in which he performed the duties of this chair—not to mention other characteristics of a favorable nature—led to his being transferred in 1751 to the chair of medicine in the same university. In 1756 the University of Edinburgh called him to the chair of chemistry, recently made vacant by the death of Dr. Plummer. Chemistry, up to that time, had been rather neglected, but Cullen's treatment of this branch of science made it the favorite study of the students. After the death of Alston, in 1760, Cullen was chosen to complete the course of instruction in materia medica which that gentleman had begun. A few years later, about 1766, Cullen began lecturing upon the theory and practice of medicine, and he continued lecturing upon this branch of medicine up to within a few months of his death, which occurred on February 5, 1790.

Cullen was one of the greatest physicians that Great Britain ever possessed. His reputation extended from one end of Great Britain to the other, this fact being due in large measure to the great number of the students with whom he came in contact in the course of his career. His kindly and generous ways, his affability, and his habit of giving words of encouragement to his pupils—all these aided in spreading his reputation. His writings are few in number, but they possess considerable value. The titles of three of his more important books are as follows: "Nosology: or a systematic arrangement of diseases by classes, orders, genera, and species, etc." Edinburgh, 1800; "Institutions of Medicine; Physiology for the Use of Students in the University of Edinburgh," Edinburgh, 1772; "A Treatise of the Materia Medica," Edinburgh, 1789.

A. H. B.

**Culex.**—A genus of mosquitos which is common throughout North America. These insects produce serious skin irritation by their bites and carry diseases, *e.g.* filiariasis and possibly dengue. They commonly breed in rain-water barrels and temporary pools. They are readily distinguished from the malaria-carrying genus, *Anopheles*, by their clear wings, the shortness of the palpi (less than half as long as the beak), and the "humpbacked" position they assume when resting. See *Insects, poisonous*.

A. S. P.

**Cumarin.**—COUMARIN, *Cumaric Anhydride, Tonka Bean Camphor* ($C_6H_4.O.CO.CH.CH$). This is the odorous principle of a number of plants or plant parts, more especially of the tonka bean, the deer's-tongue, sweet clover or melilot, and a number of species of grasses, notably the *Anthoxanthum odoratum* L. and *Savastana odorata* (L.) Scribn. It is also largely produced artificially in several ways. It occurs in white crystals which melt at 67° C., and which are soluble in alcohol but not in water. In all of these plants it can scarcely be detected in the fresh or growing state, but develops in drying. In the tonka bean it is developed by the action of alcohol, which frequently leaves the beans with a crystalline surface, due to this substance. This is frequently rubbed off, wholly or partly, and even replaced by similarly appearing substances. Cumarin has an odor very similar to that of vanilla, and a burning taste. It is exclusively employed for perfuming and flavoring, chiefly to substitute vanilla. Large doses are said to exert a primary stimulant and a secondary paralyzant action upon the heart.

HENRY H. RUSBY.

**Cumin.**—CUMMIN. CUMINUM. The fruit of *Cuminum cyminum* L. (fam. *Umbelliferæ*), a low annual of the caraway type, probably of Asiatic origin, but extensively cultivated in China, India, and parts of Europe for its aromatic fruits. The odor and taste are strongly aromatic, but less pleasant than many others in the family, on which account it is less used in this country.

Cumin yields about three per cent. of a clear, yellow *essential oil* of spicy taste and odor, and having the general medical properties of the innocuous portion of the family. The oil is separable into *cuminol* or cuminaldehyde ($C_{10}H_{12}O$) and *cymol* ($C_{10}H_{14}$). Cumin is used everywhere in the East, and to a less extent in Europe, as a domestic flavor, and is said to be one of the components of curry powder; also an ingredient in some European liqueurs. In plasters and liniments, and in veterinary practice, it is also occasionally employed. It is an excellent carminative. The dose is gr. viij. to xxx. (0.5–2.0); of the oil, ♏ ij. to viij. (0.13–0.5).

W. P. BOLLES.

**Cupping.**—Cupping is a form of treatment, more employed formerly than now, for the relief of internal

congestion or inflammation. The idea was to draw the blood to the surface of the body. When the blood was simply attracted to the surface, the process was known as *dry cupping;* when the blood thus drawn to the surface was also abstracted by means of numerous small incisions the process was called *wet cupping.*

Dry cupping is a form of *Counterirritation* (*q.v.*); for wet cupping, see *Blood-letting.*

*Method of Application.*—The principle on which the efficacy of cupping is based is the creation of a vacuum beneath the cupping glass. This can be accomplished in two ways: (1) By using a glass which is made so that it can be attached to an exhausting syringe; and (2) by using heat to rarefy the air. This latter method is the more simple, is equally efficacious, and so is the one most commonly employed. The cupping glass (or a wine glass) is first of all warmed in hot water; the selected place for the cupping should be moistened with a hot compress to make the skin more vascular; the interior of the cupping glass is *moistened only* with a few drops of alcohol, and a small pledget of cotton dipped in alcohol is lighted and passed around the inside of the glass; this produces a large flame which lasts only for a moment, and now the cup should be quickly and evenly applied to the skin. The flame is promptly extinguished and the vacuum causes the skin to be forcibly sucked up into the cup. The edge of the cup must not be so hot as to burn the skin. To release the cup, pressure with the finger should be made on the skin near the edge of the cup until air enters, when the cup will fall off. As many cups as are necessary may be thus applied, side by side; but care must be taken that they are not placed too close to each other.

*The site for cupping* should be selected where the skin is thick and smooth, such as the loins, buttocks, nape of the neck, or pectoral region. Irregular surfaces, such as over bony prominences, and sensitive parts, such as the breasts, should be avoided.

R. J. E. Scott.

**Cupping of the Optic Disc.**—When the optic nerve head or disc is looked at by means of the ophthalmoscope it appears on the general level of the surrounding parts, and any excavation or depression of its surface is called a cup. There are two kinds, *physiological* and *pathological.*

*Physiological Excavation or Cupping of the Disc.*—This variety is met with in different degrees and forms, although varying greatly, all physiological excavations have the following characteristics: they never occupy the whole area of the optic disc, and never go deeper than the lamina cribrosa, they are always met with in both eyes, though not necessarily to the same extent; the appearance in both eyes is of marked diagnostic value. The cupping of the disc may be the sloping variety, or so shaped that the edges of the cup seem to overhang.

In tracing the blood-vessels in a steep cupping along the disc toward its center they seem suddenly to come to an end, due to the straight dip which they make down the side of the excavation; but they reappear. They are not in focus at the same time with those at the surface on account of the difference in level. In the funnel-shaped excavations, the vessels may be traced down the side of the cup. In all cuppings, especially in the more marked ones, the blood-vessels at their point of turning appear darker owing to the column of blood being changed.

The position of the physiological excavation usually is central, the cupping occupying sometimes two-thirds of the entire disc, but always leaving a ring of nerve fibers at the periphery.

With the upright image the depth of the excavation may be estimated by noting the differences between the lenses required to see the general fundus, if both subject and observer are emmetropic, and it requires −3 D. to see the floor of the excavation, the depth of the latter is about one millimeter, and in the same proportion up to −10 D.

By the indirect method the excavation may be recognized ophthalmoscopically by means of the lateral motions of the convex lens, for it will be seen that while the whole fundus seems to move along with the motion of the lens, the floor of the excavation apparently moves in the same direction but at a slower rate. This parallax is the more marked, the deeper the excavation.

There are some rare cases of physiological excavation involving the whole disc which makes the diagnosis difficult; Graefe called these cases amaurosis with optic nerve excavation. W. Schneigger thinks these deep excavations succeeded by atrophy have been mistaken for glaucoma; such excavations are always bilateral, whereas in glaucoma they are unilateral.

*Pathological Excavation, or Cupping of the Disc.*—Pathological cupping of the optic papilla is caused by glaucoma and atrophy of the nerve head.

The glaucoma cupping is met with at some time during the course of the disease; in all cases, the extent of the cupping does not seem to have any relation to the degree of visual defect.

When fully developed, the glaucomatous excavation shows the vessels crowded to the inner or nasal side and appearing to bend sharply round the margin of the disc in this situation, without coursing over any portion of normal papilla, the veins being distended and the arteries small.

The papilla has a grayish-blue appearance, which varies, sometimes being spotted with white near the center.

Hemorrhages may occasionally be seen in the cup; about the papilla there is usually a whitish-yellow ring, varying in width and uniform throughout, called the glaucomatous ring.

Pulsation of the retinal arteries on the cupped disc is almost certain proof of glaucoma; such arterial pulsation is very rare otherwise; it is due to resistance to the flow of blood through the retinal arteries, the current being only complete at the systole. To obtain this pulsation use the upright image, holding the ophthalmoscope in the left hand if examining the right eye, and use the forefinger of the other hand to keep up the lid and make pressure on the eyeball.

The optic disc is the weakest spot of the fundus and naturally yields to undue pressure, while at the same time it may be helped by weakness of the lamina cribrosa. It is claimed by some that the want of resistance in the lamina cribrosa is the result of inflammatory change, and that the cupping is due to that rather than to undue intraocular pressure, as excavations may be seen even before any increased tension.

*Cupping in Atrophy of the Optic Nerve.*—In cases of cupping of the optic disc due to atrophy of the optic nerve, it is sometimes difficult to distinguish between this condition and that produced by simple chronic glaucoma. The examination of the field of vision gives no help, for in each of these diseases it is apt to be contracted. Where the tension is not much changed, we must look to the glaucomatous ring, which one usually sees about the cupping, in chronic simple glaucoma, to aid us in the diagnosis.

In optic nerve atrophy the vessels are very narrow and thread-like, and the pallor of the disc is more marked to the outer side, partly due to the diminished vascularity, and also to loss of nerve tissue, leaving only the white connective elements, hence the excavation. The excavation is shallow and usually occupies the whole disc; the vessels never bend sharply over the edge of the disc, and can be seen more or less out of focus until they emerge from the nerve.

William Oliver Moore.

**Cupriaseptol.**—This is copper sulphocarbolate or phenol sulphonate. $Cu(C_6H_4.OH.SO_3)_2+6H_2O$. It is prepared by heating a mixture of sulphuric acid and phenol, and saturating the product with copper oxide. It occurs as light green crystals, is soluble in water and in alcohol; and is used in solutions varying in strength from one-fourth to one per cent. It has been recommended as an astringent, hemostatic, and antiseptic. R. J. E. Scott.

**Cuprum.**—Copper is a yellowish red metal, found free and in combination. Its symbol is Cu, atomic weight 63, and valence II. Copper is noted for its malleability, ductility, and tenacity; it is also a good conductor of heat and electricity.

General Medicinal Properties of Compounds of Copper.—As usual in the case of compounds of the heavy metals, impregnation of the blood with a copper compound tends to affect nutrition. In medicinal doses too small to produce any obvious derangement, the influence tends to the abatement of spasmodic nervous disorders, but not to a sufficient degree to enable copper to compete with zinc and other remedies as a practical antispasmodic. In excess of medicinal dosage copper salts are readily poisonous. Locally, soluble copper salts are powerful irritant astringents. Applied in concentrated form to a moist surface they combine with the albuminous elements of the part, forming a thin, practically invisible slough, and at the same time constringe and irritate. So far as the caustic effect is concerned, it is so superficial as to be of little moment, so that practically the action is simply conjoint astringency and irritation. Such action, however, may determine absorption of easily absorbable tissue, such as granulations, or the healing of indolent ulcers, or the abatement of a catarrhal process. Taken internally, in any beyond quite small dosage, the irritant action of soluble copper salts declares itself by producing at once full and free vomiting. Such vomiting is attended with little nausea or depression, and the emetic dose is itself discharged with the ejecta. Copper salts thus become available medicinally as emetics, and because of their power and promptness of action are peculiarly appropriate for the removal of poisons by vomiting. In considerable single overdose copper salts are irritant poisons.

The therapeutics of copper compounds are comprised in the applications set forth above—locally for an astringent irritant operation, internally to provoke vomiting, or in smaller dosage for an astringent effect in diarrheas. For the latter purpose, however, other astringents more agreeable than copper compounds are commonly preferred.

A single compound, only, of copper is official in the United States Pharmacopœia, namely, the *sulphate* (cupric sulphate, $CuSO_4,5H_2O$). The salt is entitled *Cupri Sulphas*, Copper Sulphate, and is the one so well known by the common name of *blue vitriol* or *bluestone*. It occurs in "large, transparent, deep blue, triclinic crystals; odorless; of a nauseous, metallic taste; slowly efflorescent in dry air. Soluble in about 2.2 parts of water, 400 parts of alcohol, and 3.5 parts of glycerin at 25° C. (77° F.), and in 0.5 part of boiling water. (U. S. P.) The salt effloresces slowly on exposure, or on moderate heating, to an opaque, pale blue powder. Cupric sulphate may be used locally in substance, a smooth crystal, with its edges rounded by a file, being selected, or cylindrical or conical pencils may be made by fusing one part of alum with two of the copper salt and shaping in suitable moulds. Lotions are made by aqueous solution, the strength ranging from one-half to two per cent. As an internal astringent the dose is about one-fifth grain (0.01); as an emetic gr. iv. (0.25) or more if the stomach is insensitive from narcotic poisoning. But if a full dose is given, and fails to produce emesis, it must be removed by the stomach tube lest undue gastric irritation result. The salt may be given in powder, mixed with powdered sugar, or in a one-per-cent. solution. It is particularly valuable in phosphorus poisoning for in addition to its emetic properties, it forms an insoluble phosphide of copper, and so prevents further absorption. Edward Curtis.
R. J. E. Scott.

**Curare.**—*Woorari. Ourari.* This is a complex mixture of inspissated juices, which, in the relatively fresh state, is used as an arrow poison by the Indians of South America. Its composition is not known, but investigations have shown that there is always present the juice of certain species of *strychnos* which are indigenous to the country. Other species of strychnos are the source of similar poisons. In Java and Borneo, *S. tiente* yields a poison also used by the natives for poisoning their arrows; in Africa, *S. incaga* Baill. and *S. kipapa* Gigl. are the source of a powerful ordeal poison; and many other species supply active poisons, among them the well-known *S. nux vomica* L. The composition of curare varies according to the tribe from which it is obtained, each tribe selecting the tree growing in its immediate neighborhood and preparing the juice according to its tribal custom. Four varieties have been described:

First, that of the Amazon valley, from *S. Castelnæana* Weddell, a large woody climber growing in most parts of Brazil, and also in Colombia and among the Andes. The bark of the stem is the part employed. Secondly, that of the upper Orinoco region, from an imperfectly known species *S. gubleri*, possibly identical with *S. toxifera* Bentham. Thirdly, the curare of British Guiana which is attributed to the just-named *S. toxifera*. And, finally, that of French Guiana, which, on the authority of Dr. Crévaux, is attributed to *S. Crévauxii* Baillon.

Curare reaches this country in small earthenware pots or gourds, into which it has been poured in a liquid state and allowed to dry. It is a dark brittle extract with a bitter taste and disagreeable odor. It is almost entirely soluble in water.

We have no definite information as to the composition and preparation of the curare supplied to our market, nor as to its source. It is, however, of a fairly definite strength and is evidently prepared in a similar manner.

*Curarine* is the active principle. It is a white crystalline body very deliquescent and alkaline. It is roughly estimated as being twenty times stronger than curare.

*Curine* is a second principle which possesses none of the characteristic action of curare.

Curare exercises a depressant action upon the peripheral terminations of the motor nerves, affecting first the voluntary and later the involuntary muscles. When it is administered in small doses the brain and sensory nerves remain unaffected, but when it is given in large doses its effects extend to the central nervous system, producing a general paralysis, with disturbed special senses and loss of consciousness. Death takes place from failure of respiration, the respiratory muscles being affected earlier than the respiratory center. Curare is rapidly absorbed and as rapidly removed from the system with the urine. In many cases of poisoning, this excretion of the poison favors the adoption of artificial respiration as a very rational mode of treatment. The kidneys begin to act quickly, and the poison may be eliminated in a few hours. After moderate doses there is a gradual failure of muscular power with loss of reflexes, and this may terminate in complete motor paralysis. The respirations are more frequent and become

shallow and labored. The pulse is increased in force and frequency. The secretion of urine becomes greater. When the drug is given in larger doses all these symptoms are aggravated. There is also some fever, with marked depression. The heart becomes feeble and the vessels are dilated; and shivering alternates with fever, trembling, and clammy perspiration. According to reports, some specimens of curare produce muscular twitching and spasms.

As a therapeutic agent curare is of little value. Its power of preventing muscular contractions has suggested its employment in all conditions in which muscular spasm is a prominent symptom. In these, however, it cannot prove of much value, as it produces its effect through the peripheral nerves, and has little or no action upon the central nervous system, such as calabar bean and similar drugs exercise. It has been employed in poisoning with strychnine, and in hydrophobia, tetanus, epilepsy, and chorea. A case of hydrophobia has been reported in which the spasms were controlled by curare in doses of from gr. $\frac{1}{3}$ to $\frac{1}{2}$, administered hypodermically, and recovery ensued. In a case of tetanus, gr. iv. were administered during twenty-four hours with success.

The dose of curare is from gr. $\frac{1}{10}$ to $\frac{1}{2}$, to be administered hypodermically. Its effects require to be carefully watched, the smallest dose being given at first, and the amount being gradually increased until the desired effect is procured. When a new supply of the drug is obtained, the same care in determining the dose is to be observed.

The rapid action of curare, when injected beneath the skin or when applied to the denuded surface, is not evident when it is administered by the stomach or bowel. This slow absorption by mucous surfaces has given rise to the idea that it has no effect when given in this way. When it is administered in larger quantities its action is equally severe. Its diminished activity is explained by the rapid elimination of the poison, which is removed almost as quickly as it is absorbed. Another explanation is that the poison is neutralized as it passes through the liver by way of the portal vein. BEAUMONT SMALL.

**Curcuma.**—TURMERIC. The rhizome of *Curcuma longa* L. (fam., *Zingiberaceæ*), a perennial, flag-like herb of India, where, as well as in other parts of Asia, it has long been cultivated.

Curcuma is distinguished in trade as "long" and "round" varieties, which for a long while were supposed to be from different plants. They are now known to be the principal and lateral rhizomes of the same. Round curcuma is about as large as a pigeon's egg, oval, flattened, rounded at the ends and encircled by the lines of numerous nodes. The long variety, which is more common, is from three to six centimeters long, and from 0.5 to one centimeter in diameter (2 in. $\times\frac{1}{3}$ in.), encircled by a number of distinctly marked nodular rings. The different varieties range in color, externally, from bright yellow (Madras) to brown (Bengal) or gray (Java); internally from deep yellow through orange and brown to nearly black. Odor strong, peculiar, not disagreeable; taste aromatic, bitterish. It contains a clear yellow *essential oil*, which is its aromatic portion, much fixed oil, resin, and a deep yellow, crystalline coloring matter, *curcumin*, which becomes carmine red with acids, and reddish-brown with alkalies.

Properties similar to those of ginger, but not much used here—either as a medicine or as a condiment. It is extensively consumed in Asia as a spice, and is the basis of curry. In the arts, turmeric is employed to dye cloths yellow; in chemistry, to a slight extent, as a test for alkalies; in pharmacy, now and then to color ointments and other preparations. It is largely employed as an addition to ground mustard, to ameliorate its acridity, generally regarded as too great to admit of the table use of the pure article, and also as an adulterant of the same in its medicinal form. HENRY H. RUSBY.

**Curettage of the Uterus.**—The scraping of the uterine cavity by specially devised instruments is an operation of considerable value in the treatment of some of the intractable forms of endometritis, as well as for the purpose of securing material for the making of microscopic diagnoses. The instruments by which this operation is performed are termed curettes, and are of two main varieties—the *dull* and the *sharp* or *cutting* instruments. The Sims and the Martin curette are probably the best forms for the purpose of treatment, while the Thomas curette is better for diagnostic purposes. A *spoon curette* is one hollowed out in the shape of a spoon. A *flushing* or *douching* curette is one having a perforated handle through which irrigating fluids may be passed during the operation of curettage.

*Indications for the Use of the Curette.*—1. To remove portions of the uterine mucosa, or of a projecting intrauterine growth, for diagnostic purposes. 2. To correct an endometritis occurring subsequently to an abortion, miscarriage, or labor at term, and due to the retention of fragments of membrane or placental tissue. 3. To remove the entire mucosa of the uterus in cases of intractable endometritis. 4. The presence of a fungous endometritis associated with severe or constant hemorrhage. 5. Membranous endometritis. 6. After a rapid progressive dilatation for the relief of dysmenorrhea.

*Technique of Uterine Curettage.*—The time of election for performing a uterine curettement is the first week after menstruation. The uterine mucosa at that time is soft and succulent and can be readily removed. Contrary to the usage of some men the patient should always be anesthetized, and she should lie in the dorsosacral position, her feet being supported in the stirrups, or, if more convenient, her thighs being held by assistants. A thorough preliminary sterilization of the external genitalia and vagina must be made, after which an Edebohl self-retaining speculum, or the ordinary Sims speculum held firmly by an assistant, should be introduced and the cervix exposed. The anterior cervical lip is then seized by a double volsellum forceps and the uterus drawn downward and forward to the vulvar orifice. At times it is found difficult to gain entrance into the external os. Especially is this true if the patient present a uterus of the infantile type with a conical cervix and a pinhole os. In some cases of this nature the operation of cervical amputation becomes necessary in order to remove the hypertrophic elongation of the portio vaginalis. In other cases a small surgeon's probe must first be introduced, or, the os permitting, a uterine sound passed, in order to render more patulous the cervical canal and to obtain an accurate knowledge of the tortuosity and depth of the canal. It is even occasionally necessary to split the cervix bilaterally before access to the canal can be had. After securing a passageway it becomes necessary to dilate the canal sufficiently to permit the introduction of the curette. For this purpose, in the narrower cervices, the small-sized instrument of Ellinger must be used, and this followed by the heavier modification of Goodell or Mathews. Dilatation to the extent of three-quarters to one inch or slightly more may be attempted, according to the judgment of the operator in any given case. This dilatation temporarily paralyzes the sphincter at the internal os and permits the passage of the curette, which is carefully introduced to the fundus. A systematic scraping is then carried out, including the anterior wall, the posterior wall, the fundus, the angles, and the sides of the uterine cavity. Martin's curette is probably the best for

scraping the fundus. It is customary, although not universally adopted, to flush out the uterine cavity after the curettement in order to remove all débris. For this purpose an ordinary two-way catheter may be employed. Some operators use a douche-curette, thereby removing blood, clots, and scrapings during the process of the operation. Other surgeons object to douching at any stage of the operation. Personally, I prefer to remove the débris, and for this purpose use a mild bichloride solution (1:4000) followed by a douche of sterile water or of sterile physiological salt solution. The douche should be followed by an application of tincture of iodine or iodine and carbolic acid, equal parts, to the entire uterine cavity. The vagina should first be smeared with sterile vaseline, prior to the medication of the uterine cavity, in order to prevent painful irritation or even ulceration of its walls by the overflow of the medicament. All excess should be removed from the portio vaginalis and vagina by pledgets of cotton. Very rarely is a packing of sterile or iodoform gauze required after the operation of curettage. The only indication for such a packing would be excessive bleeding, such as may occur in a membranous endometritis.

*Accidents of Curettage.*—Perforation of the uterine wall, when the latter has become soft and spongy as the result of pathological changes, occasionally happens during the operation of curettage. It is also especially liable to occur in curettement after a labor or an abortion. The only prophylaxis is the most careful use of the instruments with fingers that are sensitive from long experience, without using undue haste or pressure in the operation. Another possible accident is that associated with the preliminary process of cervical dilatation, namely, a splitting of the cervix to or above the vaginal vault. Such an accident may be accompanied by excessive hemorrhage from tear of the circular artery of the cervix. A temporary tampon with sterile gauze until a ligature can be applied is the proper course to pursue under these circumstances. Finally, the possibility of the introduction of septic germs during the operation must not be overlooked. When these germs gain access to the uterine cavity they are prone to set up a suppurative inflammation which may be followed by necrotic changes in the inflamed tissues with possible perforation of the uterine wall.

*Regeneration of the Uterine Mucosa.*—The entire mucous membrane is not removed in the operation of curettage, nor destroyed, as in the operation of atmocausis. Owing to the deep implantation of the utricular glands, which penetrate well into the muscular coat of the uterus, the larger portion of these glands remains after the operation. These distal glandular portions quickly reproduce the mucosa, and this new-formed mucous membrane is very apt to be healthy. Occasionally two or more curettements will be necessary before the mucosa is reproduced in a perfectly healthy condition, especially in that interesting disease known as membranous endometritis.

*Fecundity after Curettage.*—Certain menstrual disturbances may be noted subsequent to the operation. Thus, it is not at all uncommon for the following menstruation, and occasionally that for two or three months, to be absent. Generally, however, the subsequent menstruations are normal and comparatively painless. Not infrequently a woman hitherto sterile will conceive within a short period after the operation. In a given series of fifty-two cases, recently reported, pregnancy shortly followed in thirty per cent., and in one case as early as five weeks after the curettement.

W. A. Newman Dorland.

**Curschmann, Heinrich.**—Born at Giessen, Germany, June 28, 1846. In 1875 he received the degree of Doctor of Medicine from the University of Berlin. In 1879 he was called to Hamburg to take charge of the Government Hospitals of that city, and he retained this position up to the autumn of 1888, when he accepted an invitation to fill the Chair of Clinical Medicine, and to be Director of the Medical Clinic, in the University of Leipzig. Up to the time of his death, May 6, 1910, he still held these positions, and to his ability as an organizer is largely due the high rank Leipzig holds as a medical center to-day.

Fig. 1624.—Heinrich Curschmann.

Of his published writings, which relate to a great variety of medical topics, the titles of only a few of the more important ones may here be mentioned: "Ueber das Verhältniss der Halbcirkelcanäle des Ohrlabyrinths zum Körpergleichgewicht," Archiv für Psych. u. Nervenkr., 1874; "Ueber psychische Hemianopsie," Verhandl. d. Congr. für innere Med., 1887; "Zur Lehre vom traumatischen Leberabscess," Deutsche Klinik, 1874; "Klinische Abbildungen mit Text," Berlin, 1894; and "Der Unterleibstyphus," in Nothnagel's Handbuch, 1898. A. H. B.

**Curtis, Edward.**—An American physician who flourished during the second half of the nineteenth century, and who obtained distinction chiefly in the field of scientific medicine. He was born in Providence, Rhode Island, in 1837, and graduated with high honors from Harvard College in 1859. He then entered the College of Physicians and Surgeons in New York, but the breaking out of the Civil War interfered with his medical education; and, instead of pursuing the regular course of instruction in that institution, he entered the Union Army as an officer on the staff of the Surgeon-general. About two years later he resigned from the army and resumed his medical studies at the University of Pennsylvania, from which institution he received the degree of Doctor of Medicine in 1864. Upon the cessation of the war, in 1865, Dr. Curtis sought for and obtained a position in the microscopical department of the Army Medical Museum, where he took an active part in developing the embryo art of microphotography, the results of which work gained a worldwide celebrity for the microscopic department of the museum. In 1870 he resigned from the medical staff of the army and settled in New York City as a practitioner of medicine. In 1873 he was appointed Professor of Materia Medica and Therapeutics at the College of Physicians and Surgeons in that city. In 1886 he resigned this position on account of the pressure of other duties, and was appointed Professor Emeritus. During a period of twenty-eight years (from 1876 to 1904) he served as Medical Director of the Equitable Life Assurance Society. His death occurred November 28, 1912.

Apart from a number of short articles which he contributed to periodical medical literature Dr. Curtis wrote the following larger treatises on medical topics: "A Manual of General Medicinal Technology," New York, 1883; "Nature and Health," New York, 1906. He contributed the series of articles on inorganic materia medica published in the former editions of this HANDBOOK, and was also a contributor to Johnson's "Universal Cyclopedia."

A. H. B.

**Cusco, Edouard Gabriel.**—Born December 23, 1819, and educated in Paris where he received his medical degree in 1843. The same year he was appointed hospital interne; two years later he was made assistant, and in 1848 prosector, to the chair of anatomy at the Faculté de Médecine. In 1881 he was elected a member of the Academy of Medicine of Paris and in 1882

FIG. 1625.—Edouard Gabriel Cusco.

received the appointment of honorary surgeon to the hospitals. He died in April, 1894. Cusco devoted his attention chiefly to syphilology and gynecology, being the author of a number of articles on these subjects in the periodical literature. He also invented several instruments and surgical appliances, among them being the bivalve duckbill vaginal speculum which bears his name.

T. L. S.

**Cusparia.**—ANGUSTURA. The bark of *Cusparia angustura* (Rich.) Lyons (*C. febrifuga* Humb.; *Galipea cusparia* A. St. Hil., Fam. *Rutaceæ*). This is a shrub or small tree of the Orinoco River valley, exported from Bolivar. The river at this place runs in a narrow channel, called "*Angustura*" (equivalent to "The Narrows"), and this has given its name to the bark. The bark was formerly shaved off in long strips, often with wood adhering to the inner surface. More care is now taken to obtain it in quills, which, however, arrive much broken up into curved or quilled pieces. Its outer surface presents a peculiar and very characteristic appearance, being of a yellow-clay color and densely covered with small and very slightly elevated scale-like warts, which can be readily scraped off with the finger nail. It rarely reaches a fourth of an inch in thickness. The inner surface is usually marked by a transversely wavy appearance. It has a short and sharp, but by no means weak, fracture, which discloses a zone of stone cells between the periderm and inner bark and darker volatile-oil cells. It is very bitter and aromatic. Its composition indicates properties of greater importance than have yet been attributed to it. Volatile oil, to the extent of from 0.5 to 1.5 per cent., gives its aromatic, and a considerable amount of the amaroid *angusturin* its bitter properties. With these, a peculiar resin, and a little gum, occur the alkaloids *galipine*, *galipidine*, *cusparine*, *cuspareine*, and *cusparidine*, all crystallizable. The chief consumption of angustura is in South America and the West Indies, where it is highly valued as an antiperiodic and intestinal stimulant. Its use in the United States has been as an aromatic bitter. The dose is gr. x.–xlv. (0.6–3.0). Large doses have a purgative effect.

H. H. RUSBY.

**Cutireactions.**—Healthy and infected animals react differently when extracts of the organism causing the infection are applied to the skin. This difference in cutaneous reaction was applied as a diagnostic measure, first in tuberculosis by von Pirquet and later in a large number of the infectious diseases by other investigators. In many instances this difference has acquired a high diagnostic value while in others the results have so far been of doubtful utility. As a whole these cutaneous reactions, when positive, may be considered as a part of a state of sensitiveness on the part of the organism, due to the presence within it of an infection. This condition of sensitiveness has also been called allergy or anaphylaxis. They are usually of quite a high degree of specificity though unfortunately it is not seldom difficult to distinguish between a positive and a negative reaction. The cutaneous reaction is regularly less sensitive than the subcutaneous reaction and is never attended with the constitutional symptoms that are characteristic of the latter. It will be advantageous to consider the different reactions separately.

TUBERCULOSIS.—There are three forms of cutaneous reaction employed in this disease.

1. *The cutaneous reaction* of von Pirquet. The material used is Koch's old tuberculin. This is made by filtration of a four to six weeks old culture of the tubercle bacillus in five per cent. glycerin bouillon and evaporation of the filtrate to one-tenth of its former volume. The technique of the reaction is as follows: "The patient's forearm on the inner side is cleansed with ether; two drops of the pure undiluted old tuberculin are placed upon the skin about ten centimeters apart and then the skin is scarified first between the two drops for the purpose of a control, and next within each of these drops. (A boring scarifier devised for this works very easily.) Finally a piece of cotton is placed upon each of these drops and allowed to remain for ten minutes, after which the cotton is removed. A dressing is not necessary." A traumatic reaction is first observed consisting of a small wheal with a reddened margin. This passes away in a few hours leaving a small dry scab. The specific reaction appears later only in the upper and lower scarifications where the tuberculin has been applied. It consists of a red indurated papule which extends in size and elevation measuring from ten to thirty millimeters in diameter. It usually appears within twenty-four hours and by the end of forty-eight hours has reached its maximum. It persists for one or two days and then begins to fade. In unusual instances the specific reaction may be delayed for as long as two weeks and then suddenly become positive under the influence of some other process such as a subcutaneous injection of tuberculin.

2. The *intracutaneous reaction* where a minimal amount of tuberculin is injected into the skin so as to cause an infiltration of the skin. A papule much like that in the cutaneous reaction appears in the skin of a person who reacts positively.

3. The *percutaneous reaction* of Moro. The material used is a fifty per cent. ointment of old tuberculin in lanolin. The technique is as follows: An area of skin about ten centimeters in diameter, free from hair or shaved for the purpose and usually located on the chest or abdomen is vigorously rubbed with a

piece of soft gauze moistened with alcohol, care being taken that the skin surface is not injured. Then a quantity of the ointment of about the size of a French pea is thoroughly rubbed into the cleansed area. No further attention is necessary. A specific reaction consists in the development of small nodular or papular efflorescences which usually appear within forty-eight hours but which may be delayed for four or five days.

The chief cause for difficulty in the interpretation of the reaction lies in the fact that a very large number of individuals have undergone a tuberculous infection at some time during life and are therefore sensitive to the test. Since of course the value of such a test lies in its ability to discover active as opposed to latent or healed cases, it is obvious that in adults this reaction will give the clinician much less information than when applied to infants or young children. The reaction further is apt to be negative in advanced cases of tuberculosis accompanied with marked cachexia. A comparison of the three tests would show that the intracutaneous test is the most sensitive and unless carefully done is apt to evoke a constitutional response. The cutaneous test is somewhat less sensitive while the percutaneous test is only slightly less sensitive than the cutaneous provided that the ointment be rubbed in vigorously. In children the von Pirquet reaction is far more specific than in adults and when positive possesses a high diagnostic value, this value being the greater, the less the age of the child. In adults a negative reaction in the absence of cachexia has also great value. The technique of the von Pirquet reaction is simple and its results are more uniform so that it is used much more frequently than either of the two other forms.

Glanders.—Mallein has been produced from cultures of the glanders bacillus and has been used quite extensively in the diagnosis of glanders in animals. Vallée used a cutaneous reaction and describes an intense papule formation beginning within eight hours from the application of the material. A percutaneous reaction has also been used.

Leprosy.—Leprolin has been used in leprosy in a manner analogous to tuberculin though the cutaneous reaction has been unsatisfactory, probably due to the fact that the extract was too weak. Leprolin and tuberculin are apparently closely related since leprolin causes fever in tuberculous individuals and *vice versa*.

Ringworm.—Bloch performed a cutaneous reaction with trichophytin, a filtrate of a bouillon culture. A flat red papule appeared after from four to twenty-four hours. It caused intense itching and developed for twenty-four hours after which it receded slowly. Of course in a disease in which the diagnosis is so easily confirmed by examination of the infected area, such a reaction has but little standing as a diagnostic measure.

Typhoid Fever.—The material used has been a salt solution extract of an emulsion of typhoid bacilli of high virulence. The technique used is the same as that of the cutaneous test in tuberculosis. In the few cases in which it has been tried the reaction has been positive only in the active stage of the disease and has occasionally been positive in patients that pretty surely were not suffering with typhoid fever. The blood culture and the agglutination test are so regularly of aid in the diagnosis of this infection that a cutaneous reaction would find but a small field unless its results were very accurate. It is sufficient to say that the reaction is but little used.

Syphilis.—Attempts have been made by a large number of investigators to obtain cutaneous reactions in syphilis by the injection of syphilitic material and while they are at times extremely suggestive they are as a rule uncertain and contradictory. It has been demonstrated however that the skin of syphilitics exhibits a peculiar susceptibility to traumatic irritation and may react to concentrated extract of normal liver. This condition of the skin has been called "Umstimmung." When, however, Noguchi succeeded in obtaining a pure culture of the *Treponema pallidum* the subject took on a new aspect and he was able to devise a cutaneous reaction which has proved to be of the highest value. The material was prepared in the following manner: "Pure cultures were allowed to grow for periods of six, twelve, twenty-four, and fifty days at 37° C. under anaerobic conditions. One was cultivated in ascitic fluid containing a piece of sterile placenta, and the other in ascitic fluid agar also containing placenta. The lower portion of each solid culture in which a dense growth had occurred was cut out and the tissue removed. The agar columns which contained innumerable spirochætæ were then carefully ground in a sterile mortar. The resulting thick paste was gradually diluted by adding, little by little, the fluid culture until the emulsion became perfectly liquid. The preparation was next heated to 60° C. for sixty minutes and one-half per cent. carbolic acid added. When examined under the dark-field microscope, forty to one hundred dead pallida per field could be seen. Cultures from this suspension remained sterile." The preparation is called luetin. A similar emulsion of uninoculated media was prepared for control purposes. In the application of the test the skin is cleansed with alcohol and 0.05 c.c. is injected intracutaneously with a very fine needle. The outer side of the upper arm is the site selected, one arm being used for the luetin and the other for the control. "When the injection is successfully carried out, the epidermic layer is raised up sharply from the cutis, the pale swelling thus produced going down in from ten to fifteen minutes." In the majority of individuals a small erythematous area appears about the site of the injection and recedes within forty-eight hours. The positive reaction may take one of three forms: (*a*) A large raised reddish indurated papule surrounded by some redness appears within forty-eight hours. The size and induration increase for three or four days and then gradually recede so that the reaction disappears within one week though traces may persist for a longer period. This form of reaction is usually met with among cases of secondary syphilis undergoing regular mercurial treatment in which there are no manifest lesions at the time of the test. It is also shown by cases of congenital syphilis. (*b*) The reaction may appear as the above until the fourth or fifth day when instead of receding the papule goes on to vesicle and pustule formation. The vesicle ruptures and a crust forms. After a few days the crust falls off and the lesion heals with little or no scarring. This reaction has been found almost regularly in cases of tertiary syphilis as well as in cases of secondary or hereditary syphilis which had been treated with salvarsan. (*c*) In rare cases the reaction fades almost completely within three or four days and after ten days or more suddenly lights up and progresses to a small pustule formation as in the (*b*) type. In no instances has a constitutional reaction been observed.

The test can be accepted as of considerable negative value, since it is regularly negative in normal or non-syphilitic individuals. It is only infrequently positive in the primary and the secondary stages of the disease but is positive in a very large percentage of the hereditary and tertiary cases. It is certainly much less affected by antisyphilitic treatment than the Wassermann reaction. Its exact diagnostic value has not yet been determined but it will surely come to occupy a large place in the diagnosis of syphilis.

Ralph G. Stillman.

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**Cutis Elastica.**—*Synonyms:* Elastic skin, Cutis hyperelastica (Unna.)

This dermal rarity consists of a condition—abnormal it may be—whereby the skin can be stretched to an almost incredible extent, and upon its release, quickly returns to its original position and shape. This is a prominent characteristic.

Macroscopically there is nothing perceptible to indicate the abnormality except possibly the skin being somewhat more soft and pliable to the sense of touch when feeling or handling it. This, according to Stelwagon, is due to a loosened attachment of the connective tissue, a condition said to be normal in the cat and some of the lower animals.

In some this unusual distensibility of the skin is general, in others it is regional. There is one case on record in which the left side of the body was entirely free of the peculiarity. Duhring's case was more elastic transversely to the natural lines than when stretched parallel with them. The skin of the chest can be drawn up on the face while that of the chin can be drawn out in like manner. If while so stretched the skin be held up to the light, the cutaneous circulation may be plainly demonstrated. These individuals so blessed, or otherwise, are known as "Elastic-skin men," or "India-rubber men."

*Etiology and Pathology.*—The former is evaded by saying the condition is congenital, or a developmental freak. The latter has not been established. Seifert is reported to have had one case from which sections were made, and these examined by several men with, as might be expected, some slight differences in the findings. The dermal tissue was more or less a homogeneous mass inclosing fusiform cells, with an absence of connective-tissue cells. Williams states the latter were present but modified. There was an elongation of the vessels and nerves. Unna and Williams found also an increase of muscle fibers. To the latter they attribute the elasticity. The general condition is regarded as simulating that of myxedema.

It is to the above-described condition that Crocker contends the term dermatolysis should be restricted. Other writers, however, include under this title the condition known as cutis pendula or lax skin, in which there is an inflammatory state of the skin and subcutaneous tissues, resulting in an *inelasticity* of the skin causing it to hang in masses and folds. There appears to be some obscure relationship between this condition and that of fibroma molluscum.

For treatment of elastic skin nothing has been suggested.

Rose Hirschler.

**Cutis Pendula.**—*Synonyms:* Cutis laxa; cutis pensilis, dermatolysis, fibroma pendulum.

Definition.—A soft, pendulous, benign tumor of the skin composed of hyperplastic, loosely connected fibrous tissue.

Symptoms.—This tumor occurs often single or at times in association with one or more smaller growths, and it has been observed arising from the face, the eyebrows, the occiput, the neck, the chest, the breasts, the axillæ, the back, the arms, the abdomen, the nates, the thighs, and the labia. It varies in size from its early microscopic origin to its final maximum growth, when it may completely hide the face or may involve and surround a whole extremity in its enveloping folds, or it may cover the whole back as with an immense pack. The shape of the tumor varies with the position of the patient, for its consistence is so soft that it follows strictly the force of gravity. The soft, spongy consistence is, indeed, one of the most characteristic features of the disease and to the touch the mass feels distinctly soft and yielding and closely simulates in this respect fibroma molluscum. The skin which covers the pendulous mass is almost always of a brownish hue and exhibits varying degrees of stretching, and thus we find the follicles far apart and their mouths patulous. At times we may find growing from the surface of the tumor one or more scattered, marble-sized fibromata. A marked characteristic of the more extensive cases is their tendency to grow in folds, which have been likened to the capes of an old-fashioned driving coat or to the flounces of a lady's dress. At other times the tumors hang in long straight bands.

The subjective symptoms are usually those of physical discomfort due to the presence and weight of the tumor mass, although a few instances of hyperesthesia have been recorded.

Etiology.—In cutis pendula, as in all cases of new growths, there is often doubt as to the origin of the new formation. Von Recklinghausen has, however, demonstrated that it is a direct outgrowth from the connective tissue surrounding the nerves, glands, hair follicles, vessels, or fat globules of the skin. What causes the hyperplasia in these cases the observer is usually at a loss to determine. Radcliffe Crocker has, on the other hand, described a case in which one can undoubtedly attribute the origin to trauma.

Fig. 1626.—Cutis Pendula. (Author's case.)

Instances have been recorded in which the disease has occurred in several generations of the same family or again in members of the same generation, and thus heredity seems to play a definite rôle in a certain percentage of the cases. Sex has no apparent bearing upon the presence of the tumors.

The tissue change often makes its appearance for the first time in late childhood or the new growth may not develop until the patient is well advanced in years. In the writer's case (a Syrian woman of forty-five years) the tumor was first observed in the left breast at the age of fourteen, while the change in the right breast had existed but a few years at the time the case came under observation (Fig. 1626). The tumor, if let alone, continues to grow, often for many years,

when it finally reaches its maximum size. It is usually of slow growth, and, if proper cleanliness is exercised, remains free from the intercurrent attacks of erysipelas incident to elephantiasis, and, as a rule, escapes the ulcerations which appear in the later stages of sarcoma and of epithelioma.

Pathology.—The microscopical appearances of cutis pendula are characterized principally by changes in the derma and in the hypoderma, but there are, nevertheless, a few minor points to be noted in the epidermis. First, we find a slight disturbance of nutrition in the cells of the stratum spinosum, and secondly, a marked invasion of pigment granules in the stratum germinativum.

In the corium we find a decided increase of elastic fibers which occur in compact bundles distributed at intervals immediately below the epidermis. This hyperplasia of elastic tissue is not noticed in the deeper layers of the derma but is apparently confined to the subpapillary region. Below this line we come upon the tumor proper, which consists of loosely connected bundles of fibrous tissue, rich in cells (among which many mast cells appear) and enclosing in its meshwork many blood-vessels and lymph spaces, and it is the presence of these abundant nuclei, the loose formation of the connective tissue, and the interlying vascular and lymph spaces which render so marked the microscopical contrast between cutis pendula and keloid.

The connective-tissue fibers may possibly undergo a myxomatous degeneration, and at times large foci of jelly-like material may be formed within the tumor mass.

Diagnosis.—The diagnosis should not be difficult. A single tumor of the skin, usually of long duration, arising from almost any part of the body, save the soles of the feet or the palms of the hands, hanging in one or more folds or simply pendulously from its point of support, distinctly soft and elastic in consistence, covered with a brownish, stretched integument, should suggest most strongly pachydermatocele.

The consistence, the absence of edema, the rarity of intercurrent attacks of erysipelas and of other forms of dermatitis, the frequent seat of the lesion on parts of the body unknown as points of departure in elephantiasis should render the differential diagnosis between this disease and elephantiasis Arabum comparatively easy.

The large size, the dependence, the frequent occurrence in folds and convolutions should exclude the probability of lipoma.

The pendulousness, the brown rather than the dull red or purplish color, the continued good health of the patient, the absence of metastases or of ulcerations should exclude the possibility of sarcoma.

Finally, the fact that the tumor is large, that it is pendulous, and that its covering is usually brown should lead the diagnostician to place this new growth in a separate division from the more frequent cases of multiple fibroma which it so closely resembles histologically.

Prognosis.—The prognosis *quoad vitam* is favorable, for the tumor forms no metastases and undergoes ulceration but rarely. The patient has to dread, therefore, only the disfigurement when the disease exists upon the head, the face, or the neck, or the sense of weight when the tumor attains large size, and finally the rather remote possibility of transmission to his descendants.

Treatment.—There is only one form of treatment and that lies in the removal of the tumor with the knife.

Charles J. White.

**Cuttlefish Bone.**—A very light and fragile calcareous skeleton found in the cuttlefish, *Sepia officinalis* L. (order, *Dibranchiata, Loliginea*). The "bone" of this Mediterranean mollusk is found in the dorsal part of the body beneath the mantle. It is obtained by collecting the mollusks and allowing them to putrefy, or by picking up those that wash ashore. When whole it is of oblong or lanceolate outline, strongly flattened, with one surface (the dorsal) hard and smooth, and one very spongy, light, and friable. The structure is very open, laminated, and light, the entire bone when dry floating upon water. Odor, none or slight; taste, saline.

There is a considerable demand for cuttlebones—partly for cage-birds and partly for dentifrices, polishing powders, face powders, etc. It consists almost entirely of carbonate of lime, with a little phosphate of lime and some animal matter. Its early use as an antacid, etc., is now of the past.

W. P. Bolles.

**Cyanides.**—The only cyanides that concern the physician are those, respectively, of *silver*, *mercury*, and *potassium*. Silver cyanide is a white insoluble powder, official in the United States Pharmacopœia under the title *Argenti Cyanidum*, but solely for pharmaceutical use, the salt being a possible source for obtaining, extemporaneously, diluted hydrocyanic acid. Mercuric cyanide is a soluble salt which will be found discussed in the article *Mercury*, and concerning which it is only necessary to remark in this place, that the salt adds to the irritant properties of the mercuric salts generally, a peculiar virulence due to the acid radicle of its composition. Potassium cyanide is a soluble, and therefore physiologically active, salt, wherein the comparatively mild properties of the basic radicle are entirely overshadowed by the intensely poisonous potency of the acid element; for hydrocyanic acid in combination with the bases of the alkalies proves itself exactly as poisonous as in its free state, so that the alkaline cyanides, in proportion to their weight in acid radicle, are the medicinal or toxic equivalents of the uncombined acid. Potassium cyanide, being therefore practically but a carrier of hydrocyanic acid, is considered under the present heading rather than among the salts of potassium generally.

*Potassium Cyanide.*—Potassium cyanide, KCN, is official in the United States Pharmacopœia under the title *Potassii Cyanidum*. It occurs in "white, opaque, amorphous pieces, or a white, granular powder, odorless when perfectly dry; deliquescent in the air and exhaling the odor of hydrocyanic acid. Great caution should be used in tasting and handling this salt. Soluble in about two parts of water at 25° C. (77° F.). Boiling water dissolves its own weight of the salt, but rapidly decomposes it. In alcohol it is but sparingly soluble. At a low red heat the salt fuses." (U. S. P.) It should be kept in well-stoppered bottles, since it tends to a slow decomposition by exposure. Potassium cyanide represents, in sixty-five parts, thirty-nine parts of basic and twenty-six of acid radicle; and so, according to what has been said above concerning the alkaline cyanides generally, about two and a half parts of this salt represent, physiologically, the virtues of one part of anhydrous hydrocyanic acid. The salt in concentrated application is very painful to raw and sensitive parts, and taken internally acts precisely after the manner of hydrocyanic acid, except that it is rather slower of operation. A dose anywhere between gr. iij. to v. (0.2–0.3) is ordinarily fatal, and death commonly results in from fifteen minutes to two hours. Poisoning can arise also from absorption, externally, through abrasions, and even the inhalation, in a close chamber like a photographer's "dark room," of the fumes arising from an exposed strong solution may excite symptoms. In case of poisoning by the internal taking of the salt, Taylor advocates the giving of ferrous

sulphate as a special antidote, because of the reaction between the two salts whereby the insoluble and innocent substance *Prussian blue* is formed. The same author cites the case of a photographer who, upon accidentally swallowing a solution of potassium cyanide, immediately drank of a photographic "developing" solution containing ferrous sulphate, vomited Prussian blue, and survived.

Medicinally, potassium cyanide is not much used, but is a possible substitute for hydrocyanic acid, proposed because of greater stability. Internally, it may be given in doses of gr. $\frac{1}{12}$ to $\frac{1}{8}$, (0.005–0.008) in water or syrup; the pharmacopœial dose is one-fifth of a grain (0.01). Many prescribe it in conjunction with vinegar or lemonade, with the view of setting free hydrocyanic acid from the salt, but the procedure is not necessary. Externally, an aqueous solution ranging from one-fifth to one per cent. in strength is occasionally prescribed as a lotion for the relief of surface pains or itching. A special use of potassium cyanide is to remove stains of silver nitrate from the skin, provided such stains are recent and not yet exposed to strong sunlight. A solution, or a moistened lump of the salt, is rubbed upon the blackened skin, and the part afterward well washed in water. Due regard must be paid to the very poisonous nature of the cyanide, and especially, application of the salt to cut or excoriated parts should carefully be avoided.

Edward Curtis.
R. J. E. Scott.

**Cyanosis.**—This word is derived from the Greek κύανος, meaning blue. It signifies a bluish discoloration of the skin and mucous membranes. The change in shade may vary from a leaden-white and gray-blue to a deep purple. When cyanosis is combined with pallor there result various ashen-gray tints, while the combination of cyanosis and jaundice produces a greenish hue. In the negro and other dusky-skinned races cyanosis can be detected only in the mucous membranes and in the skin of the nail-bed. Cyanosis should be distinguished from the slaty-blue color of the skin in argyria or poisoning by silver salts. The discoloration in cyanosis may be generalized or it may be restricted to certain areas: one may speak of a general or of a local cyanosis. Its intensity may be more pronounced in certain parts of the body than in others, and may vary from time to time. Cyanosis is more marked in the distal portions of the body, as on the terminal phalanges of the fingers and toes, particularly on the nail-beds, and in portions of the body where the skin is most transparent, as on the lips, cheeks, nose, and ears. In many cases it is quite marked on the knees. The terms "pale cyanosis" and "dark cyanosis" are occasionally used. In the former case the cutaneous capillaries are of normal width; in the latter case they are more or less dilated. Sahli points out that inasmuch as in dark cyanosis the hue is of a deeper blue than ordinary venous blood, one might attribute the color in the former partly to some cutaneous transformation.

The cause of cyanosis is a deficient oxygenation of the blood which also contains an excess of carbon dioxide, an obstruction to the normal flow of blood in the capillaries, a combination of either of these two factors, or a chemical transformation of the coloring matter of the blood. In some individuals in perfect health a certain degree of cyanosis of the lips may exist. This is observed particularly in "weather-beaten" faces and in those of the "full-blooded" type. The causes of cyanosis may be divided into four groups as follows: (1) respiratory; (2) circulatory; (3) toxic; and (4) enterogenous; and one may speak of another type of cyanosis, namely, (5) that which is associated with erythremia.

Cyanosis of Respiratory Origin.—The respiratory causes of cyanosis are all those conditions which in some way interfere with the respiratory apparatus, and thereby prevent the access of an adequate supply of oxygen to, and the free escape of carbon dioxide from, the blood. These causes include (1) those that constitute a mechanical obstruction of the air passages; (2) those that diminish the extent of respiratory surface in the lungs; (3) those that inhibit the movements of the respiratory muscles; and (4) those that cause a stasis of blood in the pulmonary capillaries.

*Mechanical obstruction of the air passages* may be the result of the presence of a foreign body or tumor in the pharynx, larynx, trachea, or any of the bronchial tubes. It may be caused by an inflammatory swelling such as a peritonsillar or retropharyngeal abscess; by a catarrhal or membranous inflammation of the larynx or trachea; by spasmodic or cicatricial stenosis of the larynx; by edema of the glottis or of the subglottic region; by strangulation; by tracheitis; by pressure on the trachea from thyroid enlargement or a deep-seated tumor in the neck; by bronchitis, or by spasmodic asthma.

*The diminution in the respiratory surface of the lungs* may be the result of an actual destruction of the lung tissue, of pressure upon the latter, or of a failure of the lung tissue normally to expand. The following conditions all serve to diminish the amount of respiratory surface available for oxygenation of the blood: pneumonia, tuberculosis, emphysema, bronchiectasis, pulmonary embolism and infarction, edema and passive congestion of the lungs, capillary bronchitis, pleural and pericardial effusions and exudates, pleural and mediastinal tumors, abscess and tumors of the lung, and an increase in intra-abdominal pressure which, transmitted through the diaphragm, presses the lungs upward and laterally against the thoracic walls. In Hodgkin's disease the swelling of the mediastinal glands often causes an intense cyanosis.

*The inhibition of the respiratory movements* may be the result of bony deformities of the thorax, of muscular paralysis, of muscular spasm, or may be of reflex action. The deformities of the thoracic skeleton include those associated with spinal caries, scoliosis and kyphosis; with rheumatoid arthritis; with rachitis; with benign and malignant tumors; with tuberculous disease of the ribs and sternum, and with the deformities secondary to pulmonary tuberculosis and empyema. Paralysis of the respiratory muscles may be the result of disease or of intoxication. Examples of the former are bulbar paralysis, poliomyelitis, diphtheritic paralysis, and progressive muscular atrophy. Curare poisoning has a peculiar selective action on the motor end plates of the respiratory muscles, thereby causing respiratory paralysis. Spasm of the respiratory muscles occurs in tetanus, tetany, strychnine poisoning, epilepsy, and puerperal eclampsia. Reflex inhibition of the respiratory movements is observed in cases of fractured rib, pleurisy, pneumonia, intercostal neuralgia, and peritonitis, and has the object of mitigating the severe pain associated with these conditions. A form of reflex inhibition is observed in acute pulmonary collapse, a condition that frequently occurs secondarily to some intraabdominal operation. By reflex inhibition of the respiratory movements of a portion of the diaphragm, there results a localized atelectasis of the lungs. Many of the cases that have in the past been diagnosed as postoperative or postanesthetic pneumonia really belong to this category.

Stasis of blood in the capillaries of the pulmonary circulation, while primarily of circulatory origin, nevertheless constitutes one of the respiratory causes of cyanosis. Mitral lesions, even when compensated, are almost always accompanied by a stasis in

the pulmonary circulation, and by secondary changes in the lung parenchyma (brown induration) in which respiratory expansion is diminished. One of the effects of impairment of the respiratory movements is to diminish the important influence on the circulation which is exerted by the aspiratory function of the thorax. Hence respiratory embarrassment leads secondarily to circulatory embarassment which may in turn increase the cyanosis produced by the former.

As regards the general aspects of the cyanosis caused by respiratory disorders, it may be stated that von Neusser pointed out that in these conditions dyspnea is more pronounced than cyanosis, while in circulatory disturbances the contrary condition is to be observed. Osler remarks that a severe grade of cyanosis is more common in emphysema than in other conditions with the exception of congenital heart-disease. He believes emphysema is the only disease in which the patient is able to go about in apparent comfort with a lividity of startling degree. In other diseases of the heart and lungs with a similar intensity of cyanosis, the patient is as a rule in bed and suffering from extreme dyspnea. In pneumonia an increasing cyanosis associated with a very feeble rapid pulse indicates a sudden early failure of the heart. In the pulmonary form of acute miliary tuberculosis there is cyanosis of the lips and finger tips, this cyanosis being more marked than in any other pulmonary condition with the exception of emphysema and the later stages of severe pneumonia. In bronchiectasis there is cyanosis on exertion. In the differential diagnosis between general miliary tuberculosis without local manifestations and typhoid fever it may be noted that in the former condition there is a greater tendency to cyanosis. Sahli points out that in pulmonary tuberculosis cyanosis does not reach as high a grade as the amount of lung impairment would lead one to expect. This is attributed to the fact that the emaciated body contains less blood and needs less oxygen than the normal body, so that the remaining healthy portions of the lungs are able to supply a sufficient amount of oxygen for the blood. In pneumonic plague cyanosis is an early symptom. One cannot draw a sharp line of demarcation between the respiratory and the circulatory causes of cyanosis, for respiratory impairment leads to circulatory embarrassment and *vice versa*.

Cyanosis of Circulatory Origin.—The circulatory causes of cyanosis include the following: diseases of the heart muscle and of the heart valves; diseases of the arteries and veins, including aneurysms; and vasomotor changes of various kinds.

*Diseases of the Heart Muscle and Heart Valves.*—Cyanosis may occur in any disease of the heart in which compensation has failed or has never been established. Cyanosis, observed most clearly in the lips, is one of the earliest manifestations of weakness of the heart muscle. In the impaired compensation accompanying mitral stenosis and mitral insufficiency the cyanosis is the result of two factors: the diminished oxygenation of the blood in the lungs on account of stasis in the pulmonary circulation, and the impaired circulation of blood in the distal parts of the body. In mitral disease even when compensation is good, cyanosis may occur particularly after slight exertion. It is the result of the increased tension of the blood in the pulmonary circulation and is therefore chiefly of respiratory character. Valvular diseases of the right side of the heart, which are usually of congenital origin, are accompanied by a greater degree of cyanosis than valvular diseases of the left side of the heart. In tricuspid regurgitation cyanosis is particularly pronounced. This is also true of pulmonary stenosis (see the following section). Disease of the mitral valve almost always produces cyanosis. Aortic lesions produce paleness rather than cyanosis. Von Neusser points out that dilatation of the great veins and cyanosis do not always run parallel. In congenital heart disease the blood is generally congested in the small vessels, producing a marked cyanosis, while the great veins are not dilated. On the other hand, in uncompensated acquired lesions the great veins contain the greater part of the engorged blood and the tendency to cyanosis is thereby decreased. Osler refers to the rarity of cyanosis in aortic insufficiency. When present in this condition cyanosis is usually due to complicating disease of some other valve or to an encroachment of the interventricular septum upon the right ventricle. In affections of the myocardium cyanosis is an important symptom. It is particularly pronounced in insufficiency of the right auricle and right ventricle.

*Congenital Heart Disease.*—Synonyms: congenital cyanosis, morbus cœruleus, "blue babies." This condition is accompanied by the most intense forms of cyanosis. This may involve the entire cutaneous surface and the mucous membranes. The lips may be indigo-blue or almost black. The patient may have the appearance of a mulatto. Marked clubbing of the fingers and toes is almost always present. The cyanosis may be more pronounced at certain times than at others. It is increased after exertion, by excitement, and by any intercurrent respiratory affection. The cyanosis is present from birth. It is caused by deficient aeration of the blood consequent on one or more congenital lesions or defects in the heart. These are stenosis of the pulmonary orifice, patency of the foramen ovale, persistence of the ductus arteriosus, defect in the interventricular septum, and stenosis and insufficiency of the tricuspid valve. In most cases of congenital heart disease several of these conditions are associated, the most common combination being pulmonary stenosis, persistent ductus arteriosus, and patent foramen ovale. More than one child in a family may be affected with one of these cardiac anomalies, six cases of patent ductus arteriosus having been reported in one family by de Camp. The lesions of the tricuspid and pulmonary valves are the result of a fetal endocarditis. The patency in the ductus arteriosus and the foramen ovale and the defect in the interventricular septum are the result of an arrest of development occurring mostly during the first two months of fetal life. Pulmonary stenosis, unlike other congenital lesions of the heart, is compatible with long life and good health, although the patient is subject to frequent attacks of bronchitis and may easily fall prey to pneumonia and tuberculosis.

Other less common cardiac anomalies are malpositions of the heart, the bilocular and trilocular heart, transposition of the pulmonary artery and aorta; hypoplasia of the arterial and venous systems, and stenosis or coarctation of the aorta.

The cause of the cyanosis in congenital heart disease has been variously explained. Some observers have contended that the cyanosis is the result of the admixture of venous and arterial blood which occurs through a patent foramen ovale or a defect in the interventricular septum. But there has been urged against this view the fact that in many cases of patent foramen ovale cyanosis does not occur. The most plausible explanation of the cyanosis is to be sought in the deficient aeration of the blood in the lungs, possibly aided, as is pointed out by Cautley, by an imperfect development of the special affinity of hemoglobin for oxygen. In some cases of congenital cyanosis no evidence of any heart lesion can be detected during life. Cyanosis and clubbing of the extremities are the most conspicuous symptoms of congenital heart disease. Paroxysmal attacks of dyspnea may occur during which the extremities may turn almost black. As mentioned above, however, cyanosis is not always present, and varies in dis-

tribution and severity. It is increased by exertion and by excitement. The cyanosis may not develop until several months or years after birth, and may be first noticed after some intercurrent illness, as pneumonia or bronchitis. Failure of the growth of the heart to keep pace with the growth of the entire body may occasion the development of the cyanosis. Cautley notes that some of the children are plum colored at first and that the color may fade or disappear as the child grows older. One striking feature of the blood in congenital heart disease is the increase in the number of red blood cells. This increase is of a compensatory nature. The erythrocytes may reach 10,000,000, the hemoglobin percentage may be 160, and the specific gravity may be 1,070. In pulmonary stenosis cyanosis does not occur until compensation fails. Cautley states that general cyanosis is most marked when the aorta arises from the right ventricle. In patent ductus arteriosus cyanosis is almost always absent, for more blood than ordinarily reaches the lungs. In congenital heart disease the growth of the child is usually retarded, there is a tendency to hemorrhage, and there is greatly impaired resistance to infection. The heat-regulating mechanism is usually defective, with the result that the child almost always feels cold. Cyanosis of the retina is usually present, the retinal vessels being tortuous and distended. A patent foramen ovale alone and uncomplicated rarely gives rise to cyanosis; this occurs only when there is a rise in pressure in the right auricle as the result of pneumonia, bronchitis, or cardiac weakness. Cyanosis in an infant at birth may be due to causes other than congenital heart defect. It may be due to asphyxia, pulmonary atelectasis, diaphragmatic hernia, or toxemia.

*Diseases of the Arteries and Veins.*—In some cases of arteriosclerosis, particularly if there are secondary or complicating changes in the heart, cyanosis may occur. Arterial thrombosis or embolism may cause a localized cyanosis. Aneurysms by pressure upon the respiratory organs may cause a pronounced cyanosis. Arteriovenous aneurysm particularly gives rise to a severe degree of cyanosis. In Raynaud's disease cyanosis of the extremities is one of the earliest manifestations. Acroasphyxia is an allied condition in which cyanosis, congestion, and coldness of the hands and feet occur in certain otherwise healthy individuals as the result of vasomotor influences of an obscure nature. In intermittent claudication cyanosis of the extremities may occur during the attacks. Cyanosis is also one of the manifestations of thromboangeitis obliterans. The bluish color of paralyzed limbs is to be attributed to vasomotor changes. Of similar origin is the cyanosis of hysteria, the cyanosis that follows exposure to intense cold, and the cyanosis accompanying edema—the *blue edema* of French authors. (l'œdème bleu des hystériques). Intense cyanosis of the hands and feet may occur in the diffuse form of scleroderma.

Local cyanosis may result from the pressure of a neoplasm or aneurysm upon a vein. Pressure upon one innominate or subclavian vein may give rise to cyanosis in the corresponding arm. Similarly cyanosis of the head may result from pressure upon the jugular or innominate vein or the descending vena cava. Cancer of the breast with secondary involvement of the axillary glands may cause a venous thrombosis with a resulting cyanosis of the corresponding arm. In inflammatory conditions such as cellulitis there is often an intense cyanosis of the overlying skin. The cyanosis occurring in burns of the skin is the result of a vascular thrombosis or of a toxic effect upon the heart.

Toxic Cyanosis.—This is not a true cyanosis but is the result of a chemical transformation of the hemoglobin of the blood. In this condition the appearance of the skin may be identical with that of cyanosis caused by respiratory or circulatory disorders. Certain drugs cause a conversion of hemoglobin into methemoglobin. The most common instance of this change is that which is produced by a number of coal-tar products popularly used as headache remedies, such as acetanilide, and phenacetin. These as well as nitrobenzol, carbon monoxide, sulphureted hydrogen, nitrous oxide, and illuminating gas, all produce a chronic cyanosis of greater or lesser intensity. Poisoning by potassium chlorate causes a methemoglobinemia as well as a pronounced hemolysis. In all cases of chronic cyanosis that cannot be otherwise explained the possibility of drug poisoning should be borne in mind. The diagnosis may be made by means of the detection of the characteristic bands of methemoglobin, sulphemoglobin, carbon-monoxide hemoglobin, etc., in the spectroscope. In potassium chlorate poisoning the cyanosis is combined with a slight yellowish tint. The cyanosis resulting from fish poisoning and from intoxication with snake venom is to be explained on the basis of a thrombosis in the vessels or a toxic effect on the heart. In a similar manner von Neusser explains the cyanosis accompanying intestinal anthrax.

Enterogenous Cyanosis.—This is a form of cyanosis of autotoxic character first described by Stockvis and Talma. In this condition intestinal disturbances are associated with the presence of severe cyanosis of the skin and mucous membranes, and with clubbed fingers. Some of the cases are associated with methemoglobinemia, and others with sulphemoglobinemia. There are fifteen or twenty cases of these conditions on record. Chronic diarrhea was present in many of the cases with methemoglobinemia. Gibson and Douglas isolated a colon organism in pure culture from the blood of their patient and on this basis proposed the name "microbic cyanosis." Osler points out that methemoglobinemia has been observed in Winckel's disease, in one case of which a staphylococcus has been isolated from the blood. In 1893 Kamen described an epidemic which broke out among the newborn infants of a lying-in hospital. This disease, which he regarded as identical with the so-called "cyanosis afebrilis" of Winckel, affected six infants of whom five died. The only symptoms were a cyanosis of the skin and brownish-black stools. The cause of this condition was found to be an infection with the *Bacillus coli*, a strain of which, isolated from the intestine of the patients, was traced to its source in the well-water of the institution. The cyanosis observed in these cases was regarded as the result of a sepsis, from the entrance of the colon bacilli into the circulation. Boycott has described an infective methemoglobinemia in white rats caused by Gaertner's bacillus. In these animals the infection causes a pronounced bluish coloration of the skin. All of these facts speak in favor of a bacterial origin of enterogenous cyanosis. In patients affected with sulphemoglobinemia there may be a marked cyanosis, or ashy, death-like pallor, yet these patients feel well, and do not suffer from dyspnea. The existence of intestinal disturbances in these cases leads Garrod to conclude that the condition is a chronic poisoning by hydrogen sulphide possibly absorbed from the intestines. Pick and Hecht state that the symptom complex of enterogenous cyanosis may be caused by congenital stenosis of the rectum.

The Cyanosis of Erythremia.—This disease which is also known as Vaquez' disease, Osler's disease, and polycythemia vera, has as its three cardinal symptoms hyperglobulia, splenomegaly, and plethora, with at times cyanosis. The cause of the disease is supposed to be a primary lesion of the erythroblastic tissue of the bone-marrow. An increased viscosity of the blood favors stasis and capillary engorgement. The skin is always congested, in warm weather of a

brick-red color and in cold weather cyanosed. The cyanosis of the face and hands may be quite pronounced. The blood is greatly increased in bulk and the red blood cells may number from seven to thirteen million in the cubic millimeter. Other symptoms are headache, flushing, giddiness, constipation, albuminuria, high blood pressure, and hemorrhages into the skin and from the mucous membranes.

Conditions Associated with Cyanosis.—Cyanotic parts of the body are usually cool, owing to the slowing of the blood current. This is particularly manifest in congenital heart disease, in which the temperature of the interior of the body as well as of the skin may be markedly lowered. The chronic cyanosis of the ends of the fingers and toes results in the development of clubbed fingers and clubbed toes, in well developed cases of which a swelling of the terminal phalanges occurs. The nails acquire an upward curve. These changes are frequently observed in bronchiectasis, empyema, chronic pulmonary tuberculosis, and congenital heart disease.

Alexander Spingarn.

**Cyclamen.**—The tuber of *Cyclamen europæum* L. (fam. *Primulaceæ*), a plant largely cultivated in the house for ornament. It contains the glucoside *cyclamin* ($C_{20}H_{34}O_{10}$), occurring as a white powder, and yielding *cyclamaretin* on decomposition. It is soluble in alcohol and forms a frothy solution with water. It is in other respects very similar to saponin, quickly developing an exceedingly burning and acrid taste, and very highly irritant to mucous membranes. It can be absorbed by rubbing upon the sound skin, and produces thus its characteristic effects. It is an irritant-purgative, emetic in over-doses, and may act as a fatal drastic poison. Its use in domestic practice is as a purgative and anthelmintic, the powdered form being given in doses of gr. xv. to xlv. (1.0–3.0).

Henry H. Rusby.

**Cyclasterion.**—The generic name given by Mallory to the parasite, *C. scarlatinalis*, which he discovered in the skin cells of scarlet fever victims. See *Protozoa.* A. S. P.

**Cyclitis.**—This is an inflammation of the ciliary body, manifested by a zone of congestion in the sclerotic coat surrounding the cornea. The character of the injection is purple and the deep-seated blood-vessels are involved. It is frequently seen in connection with iritis, in fact iridocyclitis would be an appropriate name, as the ciliary region is rarely affected without involving the iris.

The inflammation may assume serous, plastic, or purulent forms, and the severity of the attack and the prognosis will depend upon the nature of the exudate.

*Etiology.*—The inflammation may be caused by conditions existing within the eyeball, or without, such as injuries to the globe by trauma or the introduction of foreign substances into the eye, or penetrating wounds; traumatic cataract by pressure may cause it, as well as a dislocated lens acting as a foreign body. It has been known to follow operations on the eye where the wound of entry has been too far back in the ciliary region.

The *diagnosis* rests on the vascularity, the appearance of the iris and the aqueous humor, marked sensibility in the ciliary region to pressure, opacities in the vitreous humor, pain, and the deep color of the circumcorneal hyperemia. In acute cases the tension of the eyeball is increased, and in chronic forms diminished.

Exudation from the anterior part of the ciliary body causes synechiæ, and deposits on the posterior corneal surface, which when seen by the ophthalmoscope appear like very fine spots; in severe cases the exudate may cause the iris to adhere to the lens, and when of the purulent type hypopyon will be seen.

When the inflammation is long continued, changes occur in the vitreous, and occasionally shrinkage of its volume takes place causing detachment of the retina. When the iris is adherent to the lens, we frequently see the anterior chamber deepened or the surface of the iris showing inequalities.

Sympathetic ophthalmitis usually takes the form of serous iridocyclitis from the first.

*Treatment.*—Wounds of the ciliary region should be washed carefully and made aseptic, and the edges of the wound freed from any entangled tissue.

If the cyclitis is due to the rapid swelling of a traumatic cataract a linear extraction should be made; or if due to a dislocated lens, the latter should be extracted. The pupil should be kept dilated by the use of a mydriatic, such as atropine, cocaine, or the like. Hot fomentations are advisable, and in some cases blood-letting from the temple.

If of syphilitic origin, the proper constitutional remedies should be added to the local.

Should the disease continue for a very long time and the eyeball become shrunken and remain very painful, enucleation of the globe may be necessary.

Where the cyclitis is due to the presence of a foreign body in the eye, it should be removed if possible; if steel or iron by the magnet, other substances by forceps. William Oliver Moore.

**Cyclophyllidæ.**—An old order of tapeworms that included those which possessed a rostellum, four circular suckers, and pronounced segmentation, and were without a special uterine aperture. It included the important genus *Tænia.* See *Cestoda.* A. S. P.

**Cyclops.**—A genus of entomostracans, class *Crustacea*, phylum *Arthropoda*, which possess a single median eye formed by the fusion of two lateral eyes. These crustaceans are commonly known as "water fleas" and serve as intermediate hosts for the guinea-worm, being taken into the human body in drinking water. See *Nematoda.* A. S. P.

**Cyclorrhapha.**—A subdivision of the order *Diptera*, or flies, in the phylum *Arthropoda.* The adult fly possesses a lunula and usually a ptilinum. This group is subdivided into two subdivisions: (1) *C. aschiza* in which the antennæ have more than three segments and an arista, and (2) *C. schizophora* which have antennæ composed of three segments and an arista. See *Insects, poisonous.* A. S. P.

**Cydonium.**—Quince Seed. The dried ripe seeds of the common quince, *Cydonia cydonia* (L.) Lyons (*Pyrus cydonia* L.; *Cydonia vulgaris* Pers. fam. *Rosaceæ*) together with the gum in which they are naturally embedded.

The quince is a native of southwestern Asia and adjacent Europe, but the seeds are wholly the product of cultivated plants. They occur agglutinated in masses of eight to ten or more, being embedded in a colorless, transparent gum, of which about twenty per cent. is obtainable, and for which they are valued. The commercial seed is very liable to adulteration with fragments of the dried inner portions of the fruit, known in the trade as "shell." One part of quince-seed gum makes about one-hundred parts of mucilage. This has little adhesive power, but is excellent for the ordinary medicinal uses of mucilage, such as the making of collyria, demulcent drinks, etc. When

the drug was official, it was directed that the official mucilage be made by taking two parts of the seeds with ninety-eight parts of water. It should be freshly made when required for use. HENRY H. RUSBY.

**Cylindroma.**—The term cylindroma was first used by Billroth to designate a tumor observed by him, in which the most striking characteristic was the presence of hyaline masses in the form of spherules, cylinders, or branching cords. Inasmuch as this feature is not dependent upon the essential nature of the neoplasm but is the result of secondary degenerative changes that occur in a variety of neoplasms having no histiogenetic relationships, the designation cylindroma has been applied to many wholly dissimilar and unrelated growths, simply because they possessed the one common feature of hyaline cords and cylinders. Such hyaline formations may be found in fibromas, adenomas, carcinomas, sarcomas, and endotheliomas, as the result of coagulation necrosis, or mucoid, colloid, or hyaline degeneration, either of the tumor cells, basement membranes or blood-vessel walls. Various writers have endeavored to straighten out the tangle of cylindroma literature, and to limit the term, if possible, to some one form of neoplasm, in other words, to make a definite tumor entity of the cylindroma. (A review of the literature of cylindroma is given by Oberlin, *Physician and Surgeon*, May, 1912.)

From the descriptions given in the literature, and from his practical experience, the writer believes that there is a well-defined variety of neoplasm that deserves the term cylindroma because of its striking tendency to form hyaline cylinders of its blood-vessels as the result of a marked hyaline degeneration of the blood-vessel walls with obliteration of the vessel lumina, and disappearance of the cells forming the vessel walls. These neoplasms are not very rare, and are most often found in the mouth (salivary glands), parotid region and orbit (lacrymal glands). Apparently similar tumors have been reported by other writers as occurring in the meninges, peritoneum, and bones. They are usually about the size of a walnut, although occasionally much larger. The growth is slow. They are encapsulated, and when completely removed with the capsule do not recur. They do not set up metastases. The consistence is firm. On section the cut surface presents radiating strands of dense connective tissue enclosing hyaline, brittle areas in the form of cylinders, spherules, or dendritic cords. Some of the hyaline masses are mucoid in character, but the glassy substance is usually much firmer than myxomatous tissue. Microscopically these tumors are made up of a plexiform mass of blood-vessels with atypical cellular walls, running in all directions and irregularly interwoven, so that in the single section they are cut in all possible planes. The larger older blood-vessels form the hyaline cylinders and cords. The lumen of these is wholly obliterated or reduced to a minute slit or round opening, and endothelial cells are found lining the small openings. The atypical perithelial cells resemble endothelial or connective-tissue cells and are separated from the endothelium lining the vessel lumen by the hyaline substance forming the vessel wall. All stages of transition exist between the small capillary showing no hyaline and the larger hyaline vessels. The latter are found in the central portion of the neoplasm, while its periphery is made up of the younger cellular vessels, resembling in general structure a very vascular sarcoma. The growth is from the center to the periphery. The character of the cellular areas would justify the diagnosis of an angiosarcoma or endothelioma. Other areas may be classed as peritheliomas, while the portions of the neoplasm showing most marked hyaline change might be interpreted as an angioma hypertrophicum with hyaline degeneration of the vessel walls. Coarse strands of hyaline connective tissue may give the neoplasm a roughly lobulated or trabecular structure. The hyaline substance usually stains bright red with Van Gieson's. Small areas may be myxomatous. It is chiefly connective-tissue hyalin, but has been frequently mistaken for colloid, mucus, and amyloid. Myxomatous cartilage is not present in these neoplasms, and they differ from the ordinary myxochondroma of the parotid, which may, however, show hyaline blood-vessels like those of the cylindroma, but not to any extent sufficient to give a positive character to the tumor.

To this form of angiosarcoma (endothelioma, perithelioma), or angioma hypertrophicum, characterized by a slowly progressive new formation of

FIG. 1627.—Cylindroma of the Parotid Region. Hyaline vessel-walls forming the so-called hyaline cylinders. Red blood cells are present in the vessels not wholly obliterated, hence this is an angiohemosarcoma with hyaline change in the vessel walls.

atypical blood-vessels that gradually become converted into hyaline cylinders and cords, the term cylindroma, or angiosarcoma (endothelioma) cylindromatosum may with propriety be restricted. In the case of other varieties of neoplasm showing glassy cylinders resulting from mucoid or hyaline transformation of the wall of the blood-vessels, *cylindromatosum* should be used as an added descriptive term in designating the tumor, as, for example, *sarcoma cylindromatosum, fibroma cylindromatosum, adenoma cylindromatosum, carcinoma cylindromatosum*, etc. The appearances of hyaline spheres and cylinders can also be produced in epithelial tumors by the coagulation necrosis or the colloid or mucoid degeneration of the central portions of epithelial cell masses. Ribbert classes these with the cylindromas, but there is no logical reason for this, as the hyaline masses are different in nature and general character. The resemblance is not sufficiently close to classify them under the same head with tumors showing connective-tissue hyaline degeneration of the blood-vessels. Billroth's description of the tumor to which he gave the name of cylindroma leaves no doubt that the hyaline cylinders were altered blood-vessels, the hyaline material (regarded by himself as colloid or mucoid substance) appearing as a "glassy adventitia"

about the vessels; and he regarded the development of the glasslike substance as bound essentially to the vessels. Some writers (Adami et al.) regard the cylindroma as a lymphangiosarcoma (endothelioma) with hyaline change in the work of the lymph vessels. From the literature and from personal experience it seems most probable that the atypical vessels usually are blood-vessels, although the occurrence of hyaline change in a lymphangiosarcoma may take place, and such a tumor classed as a cylindroma.

To sum up, the term cylindroma should be restricted in its application to tumors of the connective-tissue group, arising from blood-vessels, characterized by the hyaline transformation of the vessel walls, slow of growth, recurrent, not setting up metastases, and usually located about the head or face, in relation usually with a serous or mucous gland. The cylindroma is, therefore, a *hemangiosarcoma* (*endothelioma* or *perithelioma*) *cylindromatosum*, that for brevity's sake may be styled simply cylindroma.

ALDRED SCOTT WARTHIN.

**Cyllin.**—Cyllin is the trade name of a coal-tar derivative. It contains a number of oxidized hydrocarbons which have a diphenyl nucleus instead of the single phenyl nucleus found in phenol. It is used as a disinfectant and deodorant, and is said to be noncaustic and non-toxic. Externally it is employed in lotions of 1 : 200 strength; internally it has been given in doses of ♏i.–v. (0.06–0.3). R. J. E. SCOTT.

**Cypress.**—*Cupressus* L. A genus (fam. *Coniferæ*) of a dozen species of temperate or subtropical regions of the northern hemisphere. The composition and properties are in general those of juniper, savin, arbor vitæ, and others of the family.

*Cypress oil* is distilled from the fresh leafy twigs of *C. sempervirens* L., the Oriental cypress of southern Asia. The evidence is conclusive that the inhalation of this oil gives marked relief from the paroxysms of whooping-cough, and favors recovery. The only method recommended for its employment is to scatter a few drops upon the pillow, or to spray it about the room, but it would appear that a suitable solution for use in the inhaler might easily be devised.

HENRY H. RUSBY.

**Cypripedium.**—*Ladies' slipper, Moccasin flower, American Valerian, Nervine.* The dried rhizome and roots of *Cypripedium hirsutum* Mill. ["*C. pubescens* Swz.," U. S. P.], or of *C. parviflorum* Salisb. (fam. *Orchidaceæ*). These plants are perennial herbs, arising from a horizontal rhizome by a pubescent, leafy, few-flowered stem half a meter or more in height. Leaves also pubescent, broadly oval, acute, parallel-nerved; flowers one to three, the most conspicuous part of which is the large inflated, pouch-like lip, in the former, one and a half to two inches long, in the latter about half as large, from which it and others in the genus derive their name. Rather common in moist woods, the latter more abundant in the Northwest.

The rhizome, with its adhering roots, is collected. It is "horizontal, bent, four inches (10 cm.) or less long, about one-eighth of an inch (3 mm.) thick; on the upper side beset with numerous circular, cup-shaped scars; closely covered below with simple, wiry roots, varying from four to twenty inches in length (10 to 50 cm.); brittle, dark brown or orange-brown; fracture short, white; odor faint, but heavy, valerian like; taste sweetish, bitter, and somewhat pungent."

It contains a *volatile oil*, a *volatile acid*, *tannic* and *gallic acids*, *resins*, *gum*, *starch*, etc. These constituents make cypripedium a gently stimulant and mild antispasmodic, of the hop and valerian kind. The dose is gr. viij. to xxx. (0.5–2.0), and it is best administered in the form of the official fluid extract, or sometimes still better in the form of a twenty-per-cent. tincture. HENRY H. RUSBY.

**Cystadenoma.**—CYSTOMA, ADENOCYSTOMA. The dilatation of the glandular spaces of an adenoma through the excessive formation of secretion gives rise to a cystic tumor which from its origin is best designated by the term cystadenoma. The growths belonging to this class are distinguished from the cysts in that in the former the cystic change is always preceded by a new formation of gland tissue which later becomes converted into cysts by the accumulation of secretions and the subsequent proliferation of the walls of the gland spaces. There is consequently in the cystadenoma a progressive formation of cysts out of newly formed glandular tissue, and to this process there is no definite limit of growth. In the true cysts such new growth of gland tissue does not occur, and there is not a continuous formation of new cysts. The difference between a cyst and a cystadenoma is essentially that existing between a gland and an adenoma. Nevertheless, it is at times very difficult to draw sharp lines of distinction between the cyst and the cystadenoma. This is especially the case in regard to the proliferation cysts, since from these the cystadenomata frequently take their origin. The differential diagnosis will rest ultimately upon the establishment of the facts concerning the formation of new gland tissue preceding the cyst development.

The earliest stages of the formation of a cystadenoma are seen in the gradual dilatation of some of the spaces of an adenoma through the overproduction of secretions. As soon as the dilatation of the gland space has reached such a point as to become visible to the naked eye on cross-section of the growth, it may be said to be cystic. With a preponderance of such cyst formation the adenoma gradually becomes changed into a cystadenoma. In its first stages of development the cystadenoma consists of numerous small cysts lying in a more or less well-developed connective-tissue stroma. The growth of some of the cysts may be more rapid than that of others, leading to the formation of a tumor containing both large and small cysts, often in such a manner that it may consist of a few large cysts bearing in their walls numerous smaller ones. The cystic change may not involve all of the glandular tissue of the adenoma, so that in or near large cysts there may be found gland tissue which contains only small cysts or appears solid. Not infrequently the gland spaces of an adenoma become cystic as soon as formed, so that the growth bears the character of a cystadenoma from the beginning without passing through a definite intermediate stage of adenoma.

Since the cystadenoma arises from numerous gland spaces it consists of many chambers (multilocular cystoma). Only through the atrophy of the intervening walls does the true cystadenoma become unilocular. In the case of a single large unilocular cyst in a proliferating adenoma the designation *unilocular cystadenoma* may be used with propriety to describe the cyst. The cyst spaces may be separated from each other by a very narrow wall of connective tissue, or by one so thick that they lie at some distance from each other. In the latter case the formation of connective tissue may be so preponderate over that of the cysts as to justify the use of the term cystadenofibroma or cystofibroma. If the connective tissue becomes myxomatous in character, as is not infrequently the case, the growth may be styled cystadenomyxoma or cystomyxoma. Occasionally the connective tissue undergoes a rapid proliferation and takes on an embryonic character. The term cystosarcoma has been applied to such

tumors, but their manner of growth does not justify their classification as sarcomata. They do not form metastases, and their growth is wholly by expansion. Hyaline change and calcification are not infrequently found in the stroma of cystadenomata, the latter often occurring in the shape of psammoma-like concretions.

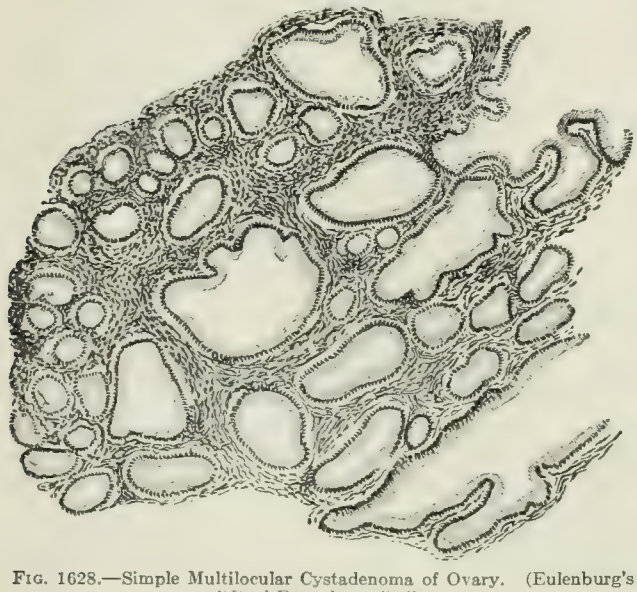


Fig. 1628.—Simple Multilocular Cystadenoma of Ovary. (Eulenburg's "Real-Encyclopaedie.")

The lining of the cysts is simple columnar epithelium in the great majority of cases, occasionally ciliated, and less frequently cubical or flattened. The inner surface of the wall may be smooth (cystoma simplex or glandulare), or the connective tissue of the wall may extend out into the cavity of the cyst as little papillæ covered with epithelium (cystoma papilliferum or proliferum). These papillæ may be delicate, simple, blunt, or pointed, or they may be dendritically branched (polypoid cystadenoma). If the growth of connective tissue in the papillæ is so extensive as partially or wholly to fill up the cyst cavity, the tumor may be designated intracanalicular cystofibroma, or intracystic papilloma. Retrograde changes not infrequently occur in the lining epithelium: mucous, fatty, or colloid-like degenerations, necrosis, desquamation, calcification, etc. Inflammation of the cyst walls may occur as in the true cysts, but is of much less frequent occurrence.

The content of the cysts is usually a clear, slightly stringy or glairy fluid like white of egg, containing mucin, pseudomucin, albumin, albumose, the so-called paralbumin, etc. All of these are the products of the lining epithelium. White or yellowish masses of cells showing fatty degeneration or necrosis may be contained in the fluid. The entire lining epithelium may be converted into goblet cells, and the latter may also be found free in the fluid of the cyst cavity. According to its contents the cystadenoma may be designated *C. serosum, C. colloides, C. pseudomucinosum,* etc. In the case of inflammation of the wall or secondary infection of the cyst contents the latter, through the addition of inflammatory exudates, become fibrinous, purulent, or gangrenous. In the latter case gas, sometimes of an inflammable nature, may be formed in the cysts. Hemorrhages may also occur into the cyst spaces. As a result of these the contents of the cysts may contain broken-down red blood cells and blood pigment, acquiring from their presence a brown or reddish-brown color. Cholesterin, fatty-acid crystals, concretions of lime salts, corpora amylacea, colloid-like bodies, etc., are not infrequently found in the cyst contents.

Cystadenomata may arise from:

1. Normal glands, most frequently from the ovaries, testes, mammary glands, uterus, liver, kidneys, and lungs.
2. Adenomata of any gland, especially from those of the ovary, mammary glands, uterus, testis, liver, pancreas and kidneys.
3. From fetal gland structures in normal or abnormal locations, from teratomata, etc.

Between the cystadenoma simplex and the papillary form no sharp line can be drawn, as papillary proliferations are frequently found in the walls of simple dilatation cysts. The two forms usually exist together in combination (cystadenoma partim simplex partim papilliferum). The papillæ may be delicate and narrow, or they may develop into thick cauliflower-like growths filling up almost the entire cyst cavity. The smallest papillary excrescences may have to the naked eye a velvety appearance. The larger papillæ are usually branched. Occasionally the connective tissue of the papillæ is myxomatous, more rarely hyaline in character. Calcification sometimes occurs in it. Tall columnar cells cover the papillæ as a rule, and the majority of these are goblet cells. The cyst contents in papillary cystadenomata consist chiefly of pseudomucin. Large numbers of desquamated and degenerating cells may be found in it. The cystadenomata of the ovaries, mammæ, and parovarium are usually papilliferous in some parts at least, while those of the liver, testis, and kidney but rarely contain papillæ.

The cystadenoma simplex is malignant only through size and position. It produces no metastases and grows only by expansion. Since it may reach an enormous size (fifty to one hundred pounds), the effects of pressure may be very important. The papillary cystadenomata represent a further departure from the normal type of gland growth, and these tumors acquire a certain tendency toward malignancy in that the papillæ may break through the cyst walls and continue to grow, spreading themselves over the neighboring tissues (in the case of ovarian cystadenomata, over the broad ligament and peritoneum, while papillary cysts of the mammæ

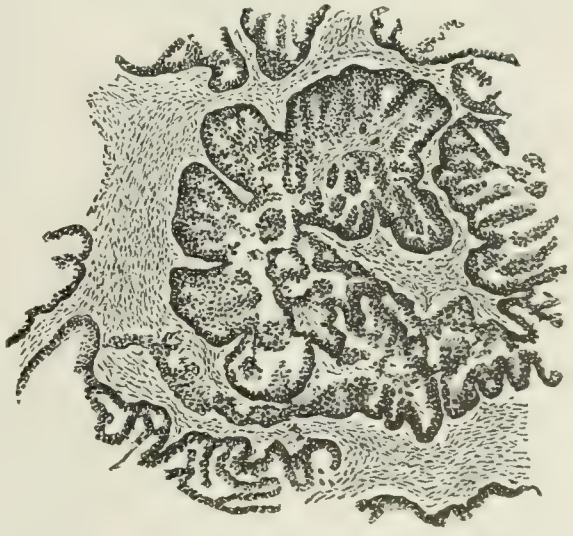


Fig. 1629.—Papilliferous Cystadenoma of Ovary. (Eulenburg's "Real-Encyclopaedie.")

may break through the skin). Cystocarcinomata not infrequently arise from the papillary cystadenomata, but may develop also out of the simple smooth-walled form. A gradual transition of development between adenoma, cystadenoma simplex, cystadenoma papilliferum, and cystocarcinoma may often be traced, and this fact is of great importance in so far as the question of etiology of tumors is concerned. Of the direct cause of the formation of the cystadenoma we have as little knowledge as of that of the adenomata in which they arise. They occur more frequently in females, as the ovaries and mammæ are the glands most commonly the seat of origin of these growths. They may develop at any age, but are most common at puberty and the menopause. Trauma, prolonged irritation and inflammation, etc., have, as in the case of other forms of tumors, been supposed to be exciting causes of growth. No satisfactory explanation can be given of the excessive cell secretion in some growths, whereby the tumor has the structure of a cystadenoma from the earliest beginnings; while in other cases the adenoma is but slowly and imperfectly converted into the cystic tumor.

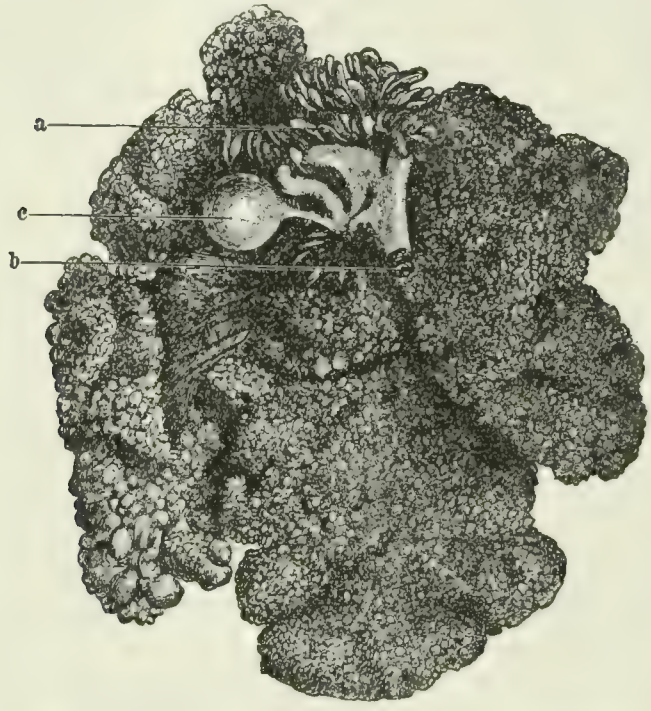



Fig. 1630.—Surface Papilloma (Cystic Papilloma) of Ovary. (Eulenburg's "Real-Encyclopedia.")

*Ovary.*—The cystadenoma is the most common form of ovarian tumor, the majority of all the large cystic tumors of this organ arising from the formation of new glandular spaces and their dilatation from the accumulation of the secretions formed by the epithelial cells lining them. They arise partly out of the follicles and partly out of in-growths of the germinal epithelium. In the latter case the in-growths become separated from the surface epithelium and form gland-like structures which gradually become distended through the formation of secretions. As the cyst develops proliferation of portions of the lining epithelium into the cyst wall takes place, these separate themselves from the parent epithelium, become dilated and form daughter cysts lying in the wall of the original cyst. This process may go on indefinitely until large multilocular growths are formed. On cross-section the inner lining of the cyst walls shows furrows and depressions at those points where the in-growth preparatory to the formation of new cysts is taking place. The partition walls of many of the cysts may atrophy, thus leading to a confluence of the chambers. Remains of the atrophic walls may appear as bridge-like projections across the lumen of the cavity. This progressive formation of daughter cysts in the wall of the cystadenoma distinguishes this growth from the degeneration cysts arising from the Graafian follicle and corpus luteum. It is, however, possible that the epithelial lining of these cysts may behave in the same way as that derived from the surface germinal layer, giving rise to epithelial in-growths that lead to the same progressive formation of daughter cysts. A similar process may be set up by proliferating in-growths from the epithelium of a follicle, which is in itself not cystic. The true cystadenoma of the ovary is always in its beginning multilocular, but may become unilocular through the disappearance of the intervening septa and the confluence of the cavities. Most commonly the growth consists of one or more large cavities in the wall of which there are countless small cysts. Traces of the septa can usually be seen in the walls of the larger cysts.

As a rule, the ovarian cystadenomata form round tumors which may be more or less nodular from the unequal development of the smaller cysts. Usually there is one large, round, chief cyst in whose walls are small nodules made up of smaller cysts. The whole has a smooth, shining, more or less translucent capsule which corresponds to the tunics of the follicles. Adhesions between the capsule and the peritoneum are common, and may be very extensive and firm. These tumors may reach a very large size and surpass in weight even that of the body. As they increase in size they usually grow out from the ovary into the abdominal cavity, remaining connected to the original site of formation by a more or less well-developed pedicel; in other cases the growth is into the broad ligament, forming intraligamentous tumors, or between the ovarian ligaments (interligamentous). The ovary, as a rule, undergoes an early pressure atrophy, the pedicel of the growth being formed by the ovarian ligaments, tube, and broad ligament, all of which become very much changed from the stretching to which they are subjected. The nourishment of the growth is to a large extent supplied by the development of blood-vessels in the inflammatory adhesions which are formed between it and the neighboring structures. As the tumor increases in size it gradually rises out of the pelvis into the abdominal cavity. Torsion of the pedicel may lead to complete necrosis of the tumor, and the resulting peritonitis and intoxication caused by the absorption of poisonous products are not infrequently fatal. Retrograde changes are also very common: hemorrhage, suppuration, etc. Thin-walled cysts may burst and discharge their contents into the abdominal cavity. In this way large masses of mucin or colloid-containing material may be spread all over the peritoneal surface, often to the depth of several inches. This is partly absorbed and partly indergoes a partial organization (pseudomyxoma peritonei). Transplanted portions of the cyst epithelium lying in this may undergo proliferation and form cysts similar to the parent growth after the manner of a true metastasis. After rupture the cyst walls may become glued together by fibroblastic adhesions and so complete obliteration may ultimately take place.

Three forms of ovarian cystadenomata may be recognized: the cystadenoma simplex, the papilliferous form, and the cystic papilloma.

The *simple cystadenoma* (*cystadenoma glandulare pseudomucinosum*) has smooth inner walls lined with columnar cells which for the greater part are goblet cells, and also frequently show fatty degeneration, or necrosis. Calcareous plates may be formed in such degenerating epithelium. The contents are usually of the nature of glairy mucus, but may be serous, or thick and colloid-like. They may be much changed in character by products derived from the degenerating epithelium, by hemorrhages, or by inflammatory exudates. Pseudomucin is constantly found in the contents, but the proportion present differs very much in different tumors. It is a mucoid body which, on boiling with acids, yields a reducing substance, does not coagulate on boiling, and differs from mucin in that it is not precipitated by acetic acid. The so-called paralbumin found in the cyst contents is only a mixture of albumin and pseudomucin. The cystadenoma simplex is a benign tumor in that it grows only by expansion, and produces no hematogenous or lymphogenous metastases. Rarely it spreads over the peritoneum by means of implantation metastasis after rupture of its walls.

The *papillary form* (*cystadenoma papillare serosum*) *of the ovarian cystoma* arises in the same manner as the simple form, but differs from it in its tendency toward proliferations of its lining epithelium, not only into the wall in the formation of new cysts but also in the shape of projections into the cyst cavities. The connective tissue of the stroma follows these epithelial buds so that a true papillary formation is brought about. This process may be observed in all stages in different cysts, from the formation of small epithelial buds giving a velvety appearance to the wall when seen by the naked eye, up to the complete filling of the cavity with a cauliflower-like mass of dendritically-branching papillæ. The proliferation of the papillæ may go so far as to lead to perforation of the walls of the tumor and the growth of the papillæ on the outer surface of the capsule, and over the neighboring peritoneum. All stages of transition forms exist between the pure cystadenoma simplex and the growths showing this excessive development of papillæ. A *cystadenoma pseudopapilliferum* may be produced by the partial atrophy of partition walls and the confluence of gland-spaces, the remains of the septa appearing as papillæ. The growth of the papillary forms is usually not so rapid as that of the simple form; it differs further from the latter in that its contents are serous, very rarely containing pseudomucin; and is most frequently double-sided in its occurrence, and rarely exceeds the size of a man's head. Its epithelium is occasionally ciliated. For this reason this form has been believed to arise from the parovarium rather than from the ovary. It has been shown, however, that the germinal epithelium under certain conditions becomes changed to ciliated epithelium. Psammoma-like concretions and calcareous plates are of very common occurrence in the papillæ of these growths. This form has, further, a greater tendency toward malignancy than has the simple cystadenoma. In about thirteen per cent. of cases the papillary cysts give rise to implantation metastases, and the development of carcinoma out of these growths is not infrequent. Sarcomatous changes are also said to take place in the stroma, but these cases are doubtful. Since the growth of the papillary forms is usually intraligamentous, their removal is attended by greater difficulties than in the case of the cystadenoma simplex.

The *cystic papilloma* of the ovary (so-called surface papilloma) forms usually a mass about the size of an orange, having a cauliflower-like surface composed of papillæ covered with simple or ciliated columnar epithelium. These growths arise for the greater part from papillary proliferations of the surface germinal epithelium; through cystic changes in these and in the ovary the growth takes on the character of a true cystadenoma. In some cases the origin is from a ruptured papilliferous cyst whose papillæ spread over the external capsule. This form shows an especial tendency to carcinomatous change, and very frequently sets up implantation metastases. It is more likely to recur than the other forms. It is most frequently one-sided, while in the other ovary there is almost always present a papilliferous cystadenoma. Ascites is almost always associated with the surface papilloma.

Cystadenomata of the ovary can also arise from ovarian teratomata, in whose glandular spaces cystic dilatation associated with epithelial proliferation is of frequent occurrence. Dermoid cysts are very often found in association with cystadenomata arising from the germinal epithelium, usually those of the smooth-walled variety. There is a growing tendency to explain all ovarian cystadenomata on the assumption of teratoid origin.

In the majority of ovarian cystadenomata the chief symptoms arise from pressure upon the neighboring organs. The uterus and tubes are pushed out of their normal positions, and in the case of very large tumors the abdominal organs may suffer a similar displacement. Pressure atrophy may result. Local or general peritonitis, inflammatory adhesions, ascites, hemorrhages, gangrene following torsion of the pedicle, purulent infection of the tumor through aspiration, etc., are among the important sequelæ of the development of these tumors. The treatment is wholly surgical.

*Parovarium.*—Cystadenomata of the parovarium are of much less frequent occurrence than those of the ovary. They arise through proliferation of the small canals of this organ, are intraligamentous, and seldom reach a large size; very rarely they grow around the tube. Their walls are smooth and lined with ciliated epithelium. They are benign in manner of growth. Occasionally they may rupture, but this event is, as a rule, not attended by serious consequences.

*Uterus.*—Cystadenomata of the wall of the uterus arising from remnants of the Wolffian duct have been described. They are not infrequently associated with myofibromata and this association is at times so intimate that they may be designated cystadenomyofibromata. Cystadenomata of the endometrium develop out of adenomatous polyps, but rarely reach a large size. They may become carcinomatous. Polypoid growths from the cervix, of the nature of cystadenomata, are much more common. They usually follow the glandular hyperplasia resulting from ectropion and laceration of the cervix, but may be of congenital origin. Carcinoma may develop from them.

*Mammary Gland.*—Next to the ovary the mammary gland is the organ most frequently affected by cystadenoma. The adenoma of the mamma is one of the most common tumors, and its gland spaces show an especial tendency to cystic dilatation. With the formation of new glandular tissue there is usually at the same time an excessive proliferation of the connective tissue of the stroma so that the resulting tumor has been called cystadenofibroma. The walls of the cysts may be smooth, but are usually more or less papilliferous. The papillæ are characteristic in that they usually take the form of broad, rounded growths into the gland spaces whose lumen they almost entirely fill. On cross-section the cyst cavities appear as narrow tortuous canals lined with epithelium; many of the papillæ may be cut in such a manner that they appear as islands of connective tissue surrounded by epithelium (intracanalicular cystofibroma). Very frequently the stroma of the papillæ becomes myxomatous in character, and occasionally it shows such marked tendency toward proliferation

that such growths have been designated as cystosarcomata. The cystadenomata of the mammæ are more malignant than the adenomata. The papilliferous forms may break through the skin and form surface growths. They very often become carcinomatous, and the present tendency with many pathologists is to class these growths with the malignant tumors.

Cystadenomata occur less frequently in the *liver* and *kidneys*. Their origin is either in adenomata arising from the bile ducts or kidney tubules or in cysts arising through some congenital disturbance of development. Cystadenomata of the *pancreas* are rare. They arise from the acini or collecting ducts. Cystadenomata of the *thyroid, prostate, testis, salivary glands, lacrymal gland, skin glands, bladder,* etc., are all of infrequent occurrence. Further, cystadenomata may arise from teratomata containing glandular tissue or from fetal inclusions of glandular type. The cystic growths found very rarely in the mediastinum and abdominal wall near the umbilicus belong to this class. The latter arises from remains of the omphalomesenteric duct. Many cystadenomata are teratoid in character, arising from disturbances of development in the Wolffian body or duct, Müllerian duct, etc. (cystadenomata of uterus and ligaments, tubes, vagina, ovaries, testes, kidney, etc.). The cystadenomata of mixed structure (cystadenomyoma, cystadenosarcoma, cystadenomyxosarcoma, etc.) are practically always teratoid in origin.

On the whole, cystadenomata are more malignant growths than adenomata. They cause greater local disturbances from their great size, give rise to secondary inflammatory changes, and are likely to rupture. The papilliferous forms may give rise to implantation metastases, and in all forms of cystadenomata there is a decided tendency toward the development of carcinoma. Recurrence after removal is also more common in the case of the papillary forms than with adenomata.

The differential *diagnosis* is based chiefly upon the presence of an elastic, fluctuating tumor. Aspiration may be of aid in diagnosis and also as a means of decreasing the size of very large cysts so as to admit of their removal. In the microscopic diagnosis of cystadenoma the chief point is the determination of the existence of a *true proliferating adenoma* in whose gland-spaces there occurs a *progressive cystic dilatation.* Hyperplastic retention-cysts, simple non-proliferating teratoid cysts, cystic inclusions of epithelium, etc., must be excluded in the differential diagnosis. The congenital cystic kidney, liver, and pancreas, and the congenital cystic lung are to be classed as disturbances of development and not as cystadenomata.

The *treatment* is wholly surgical. The *prognosis* after removal of the growth is, on the whole, very favorable, but the tendency of papilliferous cystadenomata to recur must be borne in mind. When rupture of the cyst has occurred implantation metastases should always be looked for, and the same precaution should always be taken in the case of papilliferous growths of the ovary even if rupture into the abdominal cavity has not taken place. The tendency of the cystofibromata of the mammary gland to become carcinomatous makes their early removal desirable.

ALDRED SCOTT WARTHIN.

**Cystectomy.**—See *Bladder, Extirpation of.*

**Cysticercus.**—Cysticercoid, a stage, "bladder-worm," in the development of a tapeworm which is encysted in a secondary host awaiting its final host. For example, the animal first described as *C. cellulosæ* in the pig is the cysticercus of *Tænia solium* which is a tapeworm found in the intestine of man and other mammals. The cysticercoid consists of a bladder filled with fluid and which bears a proscolex on one side of it which becomes a scolex by evagination if the bladder is swallowed by the final host. See *Cestoda.*

A. S. P.

**Cysticercus Cellulosæ Cutis.**—Multiple cysts due to the presence of the cysticercus of *Tænia solium* in the subcutaneous tissue are not infrequently encountered. Rokitansky was the first to call attention to this condition.

Most of the cases occur in countries where half-cooked pork is eaten. It is stated that five per cent. of the cases of *Tænia solium* affect the skin. The reason that few cases have been recorded is probably due to the fact that their presence causes no symptoms, and consequently the integument is not examined.

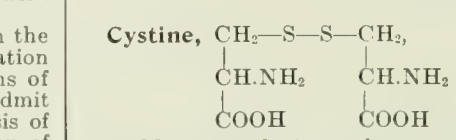
The tumors range from the size of a pea to that of a hazelnut, and may be single, but are usually multiple. They occur chiefly on the back and sides of the trunk, less frequently on the extremities. They are subcutaneous, but raise the skin into an oval-shaped tumor of a cartilaginous firmness, but withal elastic. The surface is smooth and the skin normal, unless injured by trauma or suppuration of the underlying tissues. While the animal is alive the tumor retains its elasticity, but becomes calcified into a hard nodule after its death. The differential diagnosis practically includes all subcutaneous swellings and growths.

Cysticerci also often involve the brain, and in the diagnosis any encephalopathic affection present (*e.g.* giddiness, headache, torpor, fits), and the absence of any syphilitic history, should strengthen the suspicion as to the nature of the skin affection.

The diagnosis can always be confirmed by microscopical examination of one of the tumors or of the fluid, which may be obtained through puncture. Such an examination will disclose the hooklets.

WILLIAM A. HARDAWAY.

**Cystine,**



probably occurs in traces in normal urine but in an anomaly of metabolism, cystinuria, it is found in relatively large amounts. Cystine is an amino acid, a cleavage product of protein and from it by reduction may be formed cysteine



from which in turn taurine may be formed. Cystine is also present at times in calculi. See also *Cystinuria.*

FRANK P. UNDERHILL.

**Cystinuria.**—Cystinuria (cystin, $C_3H_7NSO_2$, + Gr. οὖρον, urine), the presence of cystin in the urine, usually associated with hepatic disease and jaundice.

Cystinuria, like alcaptonuria, has attracted attention as an anomaly of metabolism that may lead to a better understanding of the normal disintegration of the protein in the body. Certain diamins, cadaverins, and putrescins characteristic of the putrefaction of proteins, are frequently found in conjunction with cystinuria, so that it has been assumed that there is an essential connection, in this condition, between alimentary putrefactive changes and the excretion of characteristic abnormal products. We have come to regard cystinuria as an abnormality of protein metabolism in which the amino-acid, cystin, a typical degradation product of albuminous substances, does not undergo further disintegration and oxidation,

such as would ordinarily occur physiologically. This view is strengthened by the simultaneous occurrence of other amino-acids, leucin, and tyrosin in certain cases. Furthermore, lysin, another amino-acid, diamino-caproic acid, has been discovered in the urine of a patient showing cystinuria. Lysin is known to be the mother substance of cadaverin, thus emphasizing the intimate interrelation of these urinary constituents and the various degradation products of albuminous substances. Cystinuria would seem to be a condition in which the normal disintegration of protein within the body is profoundly inhibited.

GEORGE E. MALSBARY.

**Cystoma.**—See *Cysts*.

**Cystomonas.**—Bodo, a genus of protozoans which contains those flagellates which lack an undulating membrane and possess two flagella, one of which is usually bent backward and kept close to the body. *C. urinaria* has been observed in urine. See *Protozoa*. A. S. P.

**Cystoscopy.**—Cystoscopy may be defined as a method of inspecting the interior of the bladder by means of an instrument introduced through the urethra. This became possible for the male bladder only when, in 1879, Nitze, of Dresden, perfected an instrument by which he could illuminate the interior

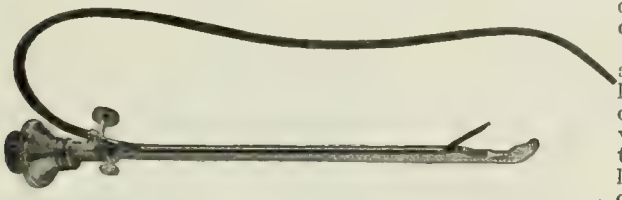


FIG. 1631.—Albarran's Catheterizing and Irrigating Cystoscope. Shows catheter in position and elevated to its full extent by the screw in the handle. (Original.)

of the bladder by a platinum wire heated to a white heat by electricity and prevented from burning the bladder wall by a constant current of cold water. The complications of this instrument, however, were such that the white hot wire soon gave place to a small Edison incandescent lamp, which greatly simplified the process and improved the illumination.

The instrument now in use retains the essential features of Nitze's cystoscope, and consists of the following parts: a shaft, a beak, a light, a window

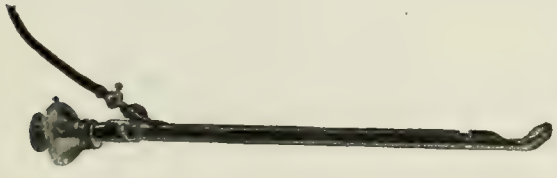


FIG. 1632.—Albarran's Catheterizing and Irrigating Cystoscope. Irrigating attachment. Water is injected into the bladder by the channel previously occupied by the catheter. (Original.)

through which the bladder wall is seen, and an optical apparatus contained in the shaft, by means of which the image is corrected and brought to the eye. The shaft is a hollow metal tube, from eight to nine and one-half inches in length, and usually of the caliber No. 22 of the French scale. At the outer end of the shaft is a funnel-shaped enlargement which contains the eyepiece of the optical apparatus and by which the instrument can be held. The beak is three-fourths of an inch in length, and is fastened to the shaft at an angle of 145°. This beak carries the lamp, and has an aperture through which the light shines. The window, through which the bladder wall is seen, is situated on either the convex or the concave side of the angle, between the beak and the shaft. When placed on the convexity of this angle it is in the axis of the shaft and admits of a direct view of the bladder wall toward which it is pointed. When the window is on the concave side of the angle the image of the bladder wall is received by a prism which turns it at a right angle into the axis of the shaft of the instrument.

The optical apparatus contained in a tube within the shaft has a lens just at the window in the bladder, and another at the end toward the observer.

The convergent rays which enter the little window within the bladder are deflected and carried up the axis of the tube to be received by the lens at the upper end; this lens again disperses them and presents to the eye an image equivalent to that received by the first lens. Thus a portion of the bladder wall much larger than the aperture is presented to the eye. The effect is much the same as if the eye were carried down to the lower opening and directly inspected the bladder through it.

In order to connect the lamp with the battery, the shaft is made of two tubes, one within the other, which are separated from each other by insulating material. Through them the current is carried and may be turned on and off by a switch attached to the handle. These tubes take up space and diminish the lumen of the instrument. To obviate this difficulty Otis devised an instrument in which the electricity is conveyed through very fine wires.

While the principle of the cystoscope has not been altered, it has undergone many modifications to enlarge its usefulness. Thus it has been found that one of the most common causes of failure to get a good view of the bladder is the presence of blood or pus in the solution with which the bladder is filled. This led to the introduction of what were called irrigating cystoscopes in which a channel was left in the shaft alongside the telescope through which the bladder could be filled and emptied at will. In some cases of troublesome bleeding it may be necessary to make the observation while a constant stream of water is kept passing through the bladder. The modern instruments of the Brown-Buerger or Bransford Lewis type enable this to be easily done.

The success which attended the efforts to catheterize the ureter in the female bladder, and the information obtained in this way, naturally led to similar attempts in the male. To this end various modifications of the cystoscope have been devised to enable the operator to introduce an ureteral catheter under the guidance of the eye.

The operation of cystoscopy is not difficult, but for its thorough performance some skill and patience are required. The interpretation of the conditions seen is by no means easy, and considerable experience is needed for the correct understanding of them.

The patient may be placed in the lithotomy position or in a half-sitting position on one of the various tables devised for the purpose, according to the individual preference of the operator.

Before introducing the cystoscope it is advisable in most cases to anesthetize the urethra with some local anesthetic. Cocaine was generally used until recent years but its tendency to produce troublesome or even dangerous toxemia has led many experts to abandon its use in favor of novocain, eucain, or alypin. Anesthesia may be produced either by the injection of a five per cent. solution into the urethra and retaining it there by pressure on the meatus or by placing a tablet of the drug in the prostatic urethra in the male and the median portion of the urethra in the female by means of a tablet depositor such as that devised by Bransford Lewis. It should be remembered that the inflamed or ulcerated bladder absorbs much more rapidly than the normal. Five or ten

minutes should be allowed for the anesthesia to become satisfactory. It is a common mistake to introduce the cystoscope before the lapse of sufficient time, thus causing unnecessary discomfort. The instrument should be passed gently in the same manner as a sound and the bladder irrigated with salt solution or two per cent. boric acid until the medium is entirely clear. Time consumed in this part of the operation is well spent as a good view is essential to correct interpretation of the picture. When the wash water returns clear the telescope is introduced and the bladder distended with 100–150 c.c. In contracted or atonic bladders the amount used must be suited to the condition, comfort being the prime consideration. The light having been turned on the examination should be conducted in an orderly manner, inspecting the base, sides and vertex in turn and then devoting attention to the parts which seem pathological.

The limits of this article will not permit of any detailed description of the cystoscopic pictures, but will confine us to a brief consideration of the conditions in which cystoscopy may be of use.

*Tumor of the Bladder.*—The cystoscope affords the most perfect opportunity for making an early and positive diagnosis of tumor. As the use of the instrument has become more and more common, tumors have been detected early, before they have outgrown the possibility of thorough and radical removal. The pictures presented by tumors are often characteristic and easily understood. On the other hand, the examination is often very difficult, or indeed impossible, by reason of the hemorrhage which prevents a clear picture.

It is well to remember that in a bladder not very fully distended the folds of mucous membrane may present misleading pictures closely simulating some forms of tumor. A mistake from this cause may usually be avoided by fully distending the bladder, and it is one which is but little likely to occur in the hands of an expert. With an irrigating cystoscope a

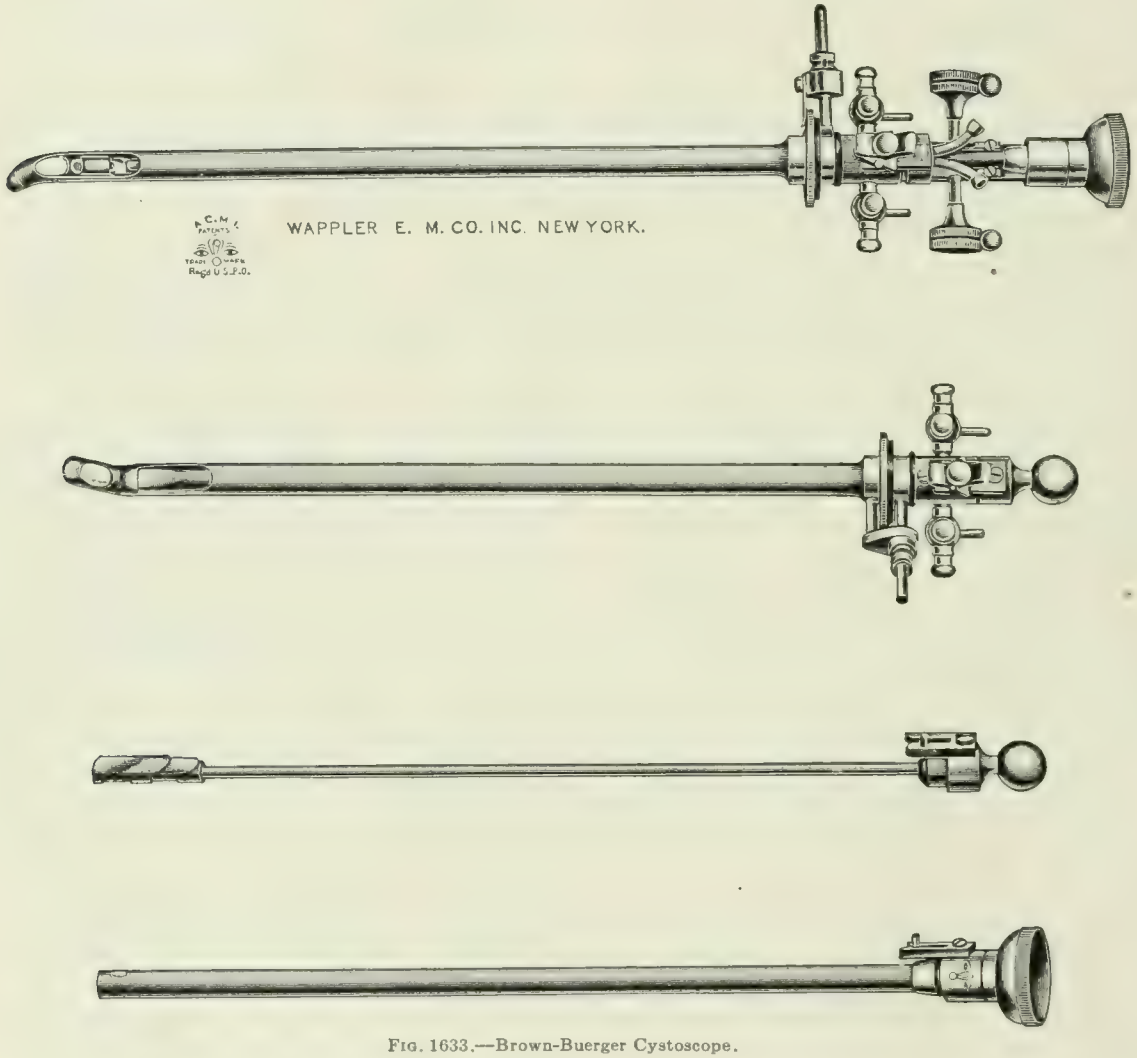



Fig. 1633.—Brown-Buerger Cystoscope.

jet of water may be thrown into the bladder during the examination, thus making a pedunculated tumor move in such a way that the operator may judge of the nature and extent of its attachment to the bladder wall.

*Examination of an Hypertrophied Prostate.*—The portions of the prostate which project back into the bladder can be quite thoroughly and satisfactorily examined through the cystoscope. The knowledge thus obtained may be of decided value in determining the operative procedure appropriate to each case.

*Stone in the Bladder.*—The cystoscope is the most efficient stone searcher. By its use a stone can be detected with certainty and the confusion arising from other conditions which simulate stone avoided. Its use should precede and follow the operation of litholapaxy.

*Sacculated Bladder.*—There are certain cases of sacculated bladder in which the cystoscope is a great aid in diagnosis. The pockets may contain stones or give rise to conditions resulting in the formation of stone, and in such cases an early and accurate diagnosis is difficult or impossible without the aid of the cystoscope. A more frequent use of this instrument might lead to a more intelligent treatment of the obscure conditions.

*Ulceration of the Bladder Wall.*—It is rare to see the bladder wall ulcerated except as the result of malignant disease or tuberculosis.

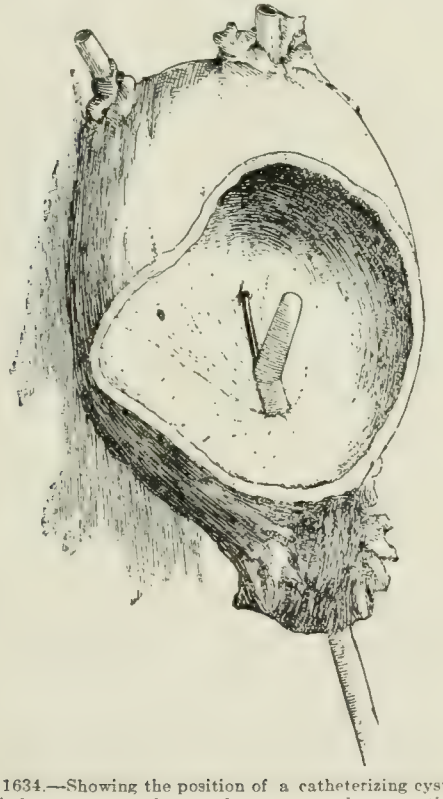


Fig. 1634.—Showing the position of a catheterizing cystoscope with window on convexity at the moment when a catheter is being introduced into the left ureter. (From F. Tilden Brown.)

*Examination of the Ureter.*—Inspection of the ureteric orifice is possible through the cystoscope and may afford valuable information as to the condition of the kidneys. In hematuria or pyuria, for example, a cloudy jet of blood or pus from the ureter convicts the corresponding kidney of being the seat of the hemorrhage, or of some inflammatory process. The desire to extend the examination further and to get still more exact information as to the condition of each kidney has led to the use of ureteral catheters, through the cystoscope. Brenner, Caspar, Albarran, Otis, Brown, Buerger, Lewis, and others have devised modifications of the cystoscope which make this procedure possible. For a more complete discussion of this subject the reader is referred to the article on *Urinary Segregation.*

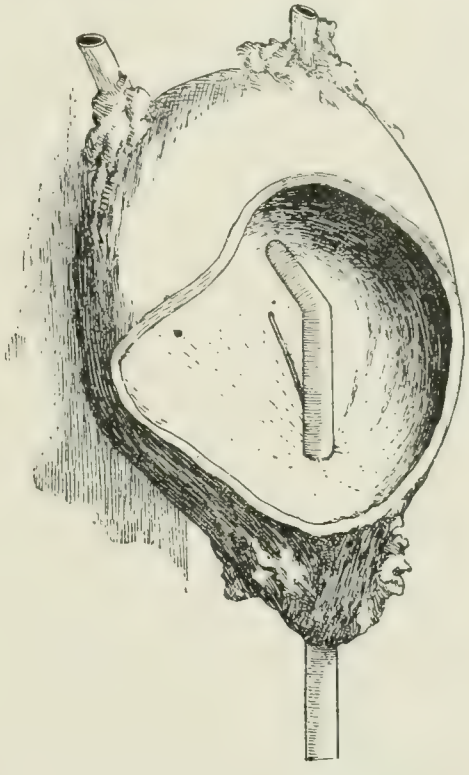


Fig. 1635.—Showing the process of catheterizing the left ureter through a cystoscope having window on the concavity. (From F. Tilden Brown.)

*Detection of Foreign Bodies.*—The cystoscope is useful in demonstrating the presence of foreign bodies in the bladder. In this way pins, silver-wire sutures, and silk sutures which were working their way into the bladder have been seen and removed.

Hugh Cabot.

**Cysts.**—A cyst is a circumscribed cavity containing a more or less fluid substance, or in rare cases gas, shut off from the neighboring tissues by a more or less independent wall, and owing its origin to pathological processes. To this definition there are, however, a number of exceptions. Pericardial, pleural, and peritoneal effusions, tuberculous cavities, abscess caverns, sinuses, etc., as well as simple dilatations of the hollow organs of the body (stomach, colon, bladder, etc.) in which the normal wall as well as the form of the organ is preserved, are not as a rule designated as cysts. Hydrocele of the tunica vaginalis is, however, illogically regarded by surgical writers as a cyst. A distinction is also made by some writers between cysts possessing a well-defined wall and those whose wall consists only of the surrounding tissue, the latter being termed cystoid. On the other hand, a distinction must be made between the true cysts and the cystic neoplasms (cystomata or cystad-

enomata). It is very difficult, however, to fix the boundary line between the cyst and the cystoma. In the development of every cyst a certain degree of proliferation of its wall must take place to compensate for the increasing size of its cavity, else defects in its wall would result. This tendency of the cyst wall to proliferation is more marked in some cases of cyst formation than in others, consequently it sometimes becomes very difficult to fix the exact nature of the cyst. As a general point of differentiation it may be taken that all cystic growths which through the proliferation of the elements of their walls constantly form new cysts are to be classed with the cystomata. In connection with such growths there is always a pathological formation of new gland tissue to which the cystic change is secondary. The character of the growth is therefore more properly expressed by the term *cystadenoma* (*q.v.*). In the true cyst the proliferation of the cyst wall is confined to that of the original cyst and there is no progressive formation of new glandular tissue. It must, however, be borne in mind that cystomata very frequently take their origin from simple cysts.

Cysts may vary in size from a pinhead to a man's head and occasionally much larger. They may consist of but one cavity (simple or unilocular cyst), or they may be many-chambered (compound or multilocular cysts). The chambers of a multilocular cyst are usually very irregular in size and shape, and may or may not communicate with each other. Communication between the cavities may occur primarily in cases in which an entire acinous gland becomes changed into a cyst, as may happen in the case of the salivary glands. Secondary communication may be established through rupture or atrophy of the partition walls. Complete destruction of these transforms a multilocular cyst into a unilocular. On the other hand, a cyst of a single cavity may through proliferation of its walls become changed to one of several or many chambers. Obliteration of a cyst cavity may result from organization or solidification of its contents, or rupture of the cyst may be followed by its collapse and subsequent union of its walls through fibroblastic adhesions. The inner wall of the cyst cavity may be smooth (simple cyst), or may be papillary (papilliferous or proliferous cyst). Cysts in their occurrence may be single or multiple. Multiple cyst formation in a number of adjacent cavities may assume the appearance of a multilocular cyst through the atrophy of the intervening tissues.

The essential elements of the cyst are the cyst wall and the cyst contents. The latter must be different in nature from the former, but both bear certain definite relations to each other. Either one or the other may be the primary agent in the formation of the cyst. In the case of the liquefaction of necrosed tissues or in the formation of a capsule around a parasite the wall is developed secondarily to the contents, while in other forms of cysts the contents are the result of secretion by the elements of the cyst wall. In these cases, however, the retention of secretions and the consequent stretching of the wall are the factors which excite further proliferation in the elements of the wall.

As a rule the cyst wall consists of a connective-tissue membrane of greater or lesser thickness separating the cyst contents from the neighboring tissues. It may be thick enough to be visible to the naked eye, or may be evident under the microscope as a very delicate fibrous layer, or only as a thickened layer of the surrounding tissues, while in other cases the cyst contents may lie in direct contact with these without any proper intervening membrane. Very frequently the cyst wall is so independently developed as to render it possible for the cyst to be easily shelled out from the surrounding tissues. In other cases the wall may become thickened through inflammatory processes and so intimately adherent to the neighboring structures that its separation from them becomes difficult or impossible. In a general way the thickness of the cyst wall will depend both upon the age of the cyst and upon the degree of pressure within it. In the early stages of formation the cyst may possess no definite wall, while later a thick fibrous capsule may gradually develop. On the other hand, an originally thick capsule may be thinned from a great increase of pressure within the cyst. Deposits of fibrin, lime salts, etc., upon the inner surface of the wall may cause its apparent thickening. The connective-tissue capsule of the cyst may have either an epithelial or an endothelial lining, or the cyst contents may lie in direct contact with the connective tissue of the wall or with the surrounding tissue. This will depend chiefly upon the anatomical origin of the cyst, the character of the inner lining of the capsule being the same as that of the cavity from which the cyst arose. Epithelium will be found only in those cysts which arise from spaces originally lined with epithelium, and from the character of the epithelial cells lining the cyst it is possible within certain limits to tell its origin. Many changes, however, take place in the character of the lining cells: originally tall columnar cells may become cuboidal or flattened, ciliated cells may be changed to simple columnar or flattened, while a single-layered epithelium may become stratified through proliferation. Increase of pressure within the cyst is the chief factor in producing these changes. For this reason the true character of the lining epithelium is best preserved in the cysts of smallest size. Under certain conditions these changed forms of epithelium revert to their original type. Cysts formed in connective tissue or from dilatation of blood or lymph spaces will be lined with endothelium. In the first case the endothelium arises from the proliferation of the endothelial cells lying in the connective-tissue spaces.

Retrograde changes are of very frequent occurrence in the cyst wall and the cells lining it. Mucous degeneration, as well as hydropic and fatty degeneration of the lining epithelium, is the most common. Desquamation and necrosis also occur, as well as pressure atrophy. Corpora amylacea and colloid-like substances are also found in cysts as the results of pathological secretion of the lining cells. In the connective-tissue capsule there may occur inflammatory processes of varied kinds, suppuration, hemorrhage, calcification, hyaline change, and even bone formation. Calcareous plates may be formed in the cyst wall or the entire wall may be completely calcified. Very rarely amyloid is found in cyst walls after inflammatory processes. As a result of changes in the capsule the lining of the cyst undergoes degeneration following the disturbance of its nutrition. Obliteration of the cyst may result from extensive changes in the wall.

The content of cysts varies greatly according to their origin. It may be serous with more or less albumin content, or it may contain mucin, pseudomucin, albumose, etc., or it may be colloid-like, hemorrhagic, purulent, or contain fat, fatty-acid crystals, cholesterin, blood pigment, etc. To the naked eye its appearance may be thin and transparent, or thick, turbid, opaque, varying in color from red, brown, greenish, or gray, to yellow and white. The consistence may be stringy, gelatinous, waxy, slimy, pultaceous, greasy, etc. In rare cases the cyst may contain only air or gas. The epithelium lining cysts produces a secretion somewhat analogous to that of the gland from which it has its origin, but owing to the retrograde changes occurring in the epithelial cells the chemical nature of the secretion comes to differ greatly from that of the normal. According to the nature of these changes it may become serous, mucous, colloid, etc.; if exudates from the cyst wall are added to it the content may become fibrinous, purulent, albuminous, etc.; or in case of hemorrhage into the cyst it may contain the remains of red cells or blood-pigment

granules. The reaction of cyst secretions is usually weakly alkaline, but it may be neutral or acid in rare cases of retention of an acid secretion. Cysts arising from the degeneration of tissues or tumors may contain portions of tissue showing sufficient structure to aid in the differential diagnosis. In cysts formed by parasites portions of the parasite may be present. In the case of cystic abdominal tumors the character of the cyst contents is of great importance in the differential diagnosis.

Classification.—Cysts are so varied in origin and character that it is difficult to classify them under a common head pathologically. Many writers group them under the tumors, but as the true cyst is not a true neoplasm this classification is misleading. The only practical basis of classification is according to etiology.

According to their origin cysts may be divided into:

1. Retention secretory cysts.
2. Follicular secretory cysts.
3. Proliferation cysts.
4. Necrotic cysts.
5. Hemorrhagic cysts.
6. Endothelial cysts.
7. Ependymal or neural cysts.
8. Congenital cysts.
9. Inclusion cysts.
10. Foreign-body cysts.
11. Parasite cysts.
12. Air or gas cysts.

*Retention Cysts.*—These arise through the dilatation of gland spaces or ducts caused by the retention of secretion due to some obstruction to the normal outflow. This is the most common form of cyst and may arise in any gland of the body possessing a duct or lumen, provided that an actively secreting parenchyma still remains behind the point of obstruction. Such cysts are therefore lined with epithelium resembling in character that of the gland in which they arise. Retention cysts lined with endothelium may arise from lymphatics, lymph spaces, synovial membranes, or tendon sheaths. The contents of retention cysts depend upon the nature of the tissue in which they are formed and upon the secondary retrograde changes present. The causes leading to the obstruction or closure of gland ducts are very varied in nature: inflammations in the gland or neighboring tissues, cicatricial contraction, thickening of secretions, calculi, new growths in or around the gland, etc. The gland duct may also be partially closed during a resting period, so that when the gland is suddenly called into activity the inadequacy of the outflow leads to a cystic dilatation. As the secretions collect behind the point of obstruction, the gland or duct becomes dilated and with the stretching of the wall there is usually a compensatory hyperplasia of the gland wall.

Retention cysts are most commonly found in the hair follicles and sebaceous glands of the skin (wens, atheromata, sebaceous cysts), glands of Bartholin, mucous glands of the alimentary tract, uterine glands, glands of the cervix uteri (ovula Nabothi), epididymis, kidney tubules, and mammary gland (galactocele); less frequently in the sweat glands, biliary ducts, pancreas (ranula pancreatica), salivary glands (ranula), lacrymal gland (dacryops), etc. Cystic dilatation of the larger canals, ureters, vermiform appendix, Fallopian tubes (hydrosalpinx), gall-bladder (hydrops cystidis felleæ), etc., may also be caused by obstruction and retention of pathological secretions and exudates. Retention cysts whose walls are composed of more than one kind of epithelium, or containing secretions from glands discharging into them are often called *composite cysts* (teratoid cysts, hydronephrosis, sequestration and implantation cysts).

*Follicular Cysts.*—Closed glandular cavities having no outlet, such as those of the thyroid, ovary (cysts of Graafian follicles and corpora lutea), parovarium, etc., become cystic when an excessive amount of secretion is formed by their walls. Such cysts are extremely common in the ovary and parovarium, being found in practically every woman after the age of thirty. They are usually of small size but may become very large. They are lined usually with a single layer of columnar cells and contain a mucoid or colloid-like substance. This may present great alterations in character due to secondary pathological changes in the cyst wall.

*Proliferation Cysts.*—As the retention or follicular cyst enlarges there must take place also a compensatory increase of the tissue elements of its wall, or else rupture from excessive thinning would eventually take place. Cyst formation is therefore not entirely of the nature of a retrograde change, but involves a certain degree of proliferation. It is consequently difficult to draw a definite line between simple proliferating cysts on the one hand and cystic neoplasms on the other. As true tumors of the latter class (cystomata or cystadenomata) may be classed all cystic growths which through the proliferation of their walls constantly form new cysts. Preceding this new cyst formation there is usually a pathological formation of new gland tissues to which the cystic change is secondary. As mentioned above such growths are therefore more properly classed as cystadenomata. Cystic tumors may also arise from newly formed lymph and blood-vessels, but these are to be classed with the angiomata. As true proliferation cysts are to be regarded those unilocular cysts which become multilocular through the proliferation of their walls, at the same time increasing greatly in size; or those cysts whose walls proliferate into the lumen of the cyst, forming papillary excrescences on the inner surface of the cyst wall. Proliferation cysts occur chiefly in the ovary, parovarium, kidneys, and cervix uteri. Between them and the true cystoma there is a gradual transition.

*Necrotic Cysts.*—Cystic spaces are very frequently formed by the liquefaction of necrosed portions of tissues or organs. They may possess no definite wall, or the space may be surrounded by a connective-tissue capsule which in some cases is lined with endothelium derived from the endothelial cells of the connective-tissue spaces. The cyst may contain portions of necrosing tissue-elements whose structure is sufficiently preserved to admit of identification. Necrotic cysts may arise as sequelæ to anemic infarctions, especially those of the brain. In the ovary they occur within certain limits as a physiological degeneration of the corpus luteum and also of the Graafian follicle after the menopause. Large extravasations of blood in the tissues, chronic abscesses, old tubercles, gummata, etc., may also become liquefied and form cysts. Necrotic cysts occur also in the bone marrow of old age, and in the thyroid, pancreas, kidneys, etc. They are also very commonly present in quickly growing malignant tumors following simple necrosis, fatty or mucous degeneration. In these cases the content of the cyst is usually cloudy or turbid, containing blood pigment and remains of tumor elements. Such degeneration cysts are especially common in myxomata and sarcomata, sometimes occurring to such a degree as to warrant the employment of such terms as cystomyxoma, cystosarcoma.

*Hemorrhagic Cysts.*—Cysts are often formed after the extravasation of blood into organs or tissues, by the formation of a capsule about the extravasate and the subsequent liquefaction of the latter. According to its age the cyst may contain blood-stained fluid, pigment, or a clear serous fluid. Such cysts are most commonly found in the brain, thyroid, ovary, Fallopian tube, scalp (cephalhematoma), muscles, pinnæ of ears (othematoma), etc.

*Endothelial Cysts.*—Degeneration cysts lined with endothelium may be formed by the proliferation of the endothelial cells of the connective-tissue spaces. Retention cysts with endothelial lining may arise from blood-vessels, lymphatic vessels and spaces, tendon sheaths, and synovial membranes. The so-called ganglion, hygroma, etc., may be placed in this category. In these cases the cyst is usually formed by the shutting off of some portion of a cavity by inflammatory adhesions or constrictions, and the dilatation of the sac so formed through the accumulations of inflammatory exudates. In the case of the ganglion the cyst is formed by a myxomatous degeneration of the connective tissue in the neighborhood of the joints, and derives its endothelium from that of the lymph spaces. It is partly a new formation and partly a degeneration. The cystic hemangiomata and lymphangiomata belong to the neoplasms and are not to be placed in this category.

*Ependymal or Neural Cysts.*—As a result of stenosis through imperfect development, pressure or inflammation there may occur a localized collection of cerebrospinal fluid in the spinal canal or cerebral ventricles (hydrocephalus internus, syringomyelocele, hydrocele of fourth ventricle, etc.). Hydrocephalus is usually due to an obstruction in the iter, while hydrocele of the fourth ventricle is caused by obstruction of the lateral recesses of the fourth ventricle.

*Congenital Cysts.*—Remains of fetal clefts, canals, and fissures in normal locations or misplaced fetal inclusions may become cystic as a result of proliferation of their walls excited by trauma, inflammation, etc., or from excessive formation of secretion. Such cysts occur in the branchial clefts, thyrolingual duct, urachus, parovarium, remains of the Wolffian body, Müller's ducts, Gärtner's duct, omphalomesenteric duct, etc. The dermoid cysts and cystic teratomata are usually classed with neoplasms. Analogous to the cysts arising from fetal inclusions are those arising from the implantation of epithelium occurring rarely as the result of trauma, inflammation, or operation (inclusion cysts). The congenital cysts due to imperfect or arrested development of glandular organs (kidney, liver, and pancreas) should be placed under this head, instead of under the cystadenomata. The predominant opinion at the present time is that they represent arrested development, but the exact nature of this disturbance is not yet known, although probably of obstructive origin. In the so-called *congenital cystic diathesis* there is multiple cyst formation ("cystic degeneration") of kidneys, liver, and pancreas; and in the case of the liver and pancreas the obstructive nature of the cyst formation is often clearly shown. A multiple cyst formation in the lung may also occur as the result of arrested development.

*Inclusion Cysts.*—Through traumatic or surgical displacement of portions of epithelium into mesoblastic tissues cysts may be formed from the resulting proliferation of the included epithelium. Kaufmann's experiments in enkatarrhaphy are well known. He found that the inclusion of portions of a cock's comb was followed by the formation of cysts lined throughout with epithelium and containing material resembling that found in atheromatous cysts. The growth of these cysts continued until a certain limit was reached when they remained stationary. Similar cysts have been observed in the human body arising from implantations of portions of epithelium after trauma to the skin and scalp. They are found more frequently in the scars of burns than after wounds. The writer has observed a case of multiple cyst formation after the removal of a portion of the jaw in a case of giant-cell sarcoma. The cysts, the largest of which was of the size of a hen's egg, were lined with stratified squamous epithelium most probably derived from the mucous membrane of the mouth. Such dislocated portions of epithelium do not possess the intrinsic capacity for unlimited growth as seen in the cell nests of epiblastic tumors. Traumatic epithelial cysts must be thoroughly removed, otherwise they may recur.

*Foreign-body Cysts.*—Around foreign bodies embedded in the tissues a capsule of connective tissue may be formed. This may undergo proliferation while degenerative changes may occur within the cyst contents. In this manner cysts may arise that partake of the nature of both degeneration and proliferation cysts. Such cysts contain in addition to the primary cause, necrosed tissue and pathological exudates from the wall.

*Parasite Cysts.*—Aside from the capsule which may be formed around a parasite, certain organisms such as the cysticercus and echinococcus may be found in the human body in the cystic stage of their development. Around the cyst formed by the parasite itself there is usually developed a connective-tissue capsule. Only rarely are the parasite cysts found free in the tissues or in the body cavities, the cysticercus being occasionally found in the meninges and ventricles of the brain. Parasite cysts may contain characteristic portions of the parasite or may be sterile.

*Air and Gas Cysts.*—Cyst-like cavities filled with air may arise from the shutting-off of portions of emphysematous lungs. Air-containing diverticula are found rarely in the pockets of Morgagni, and the mucous glands of the trachea and larynx may undergo cystic dilatation from air forced into them under high pressure. Cysts containing gas are occasionally found in the mucous membrane of the vagina. According to Zweifel the content of these cysts consists of trimethylamine. Eppinger and others hold that the condition is only an emphysema of the vaginal wall. According to Chiari's investigations the cysts are dilated lymph spaces lined with endothelium which not infrequently produces giant cells. The origin and nature of the gas filling the cyst are unknown. Similar gas cysts have also been observed in the wall of the intestines and in peritoneal adhesions. Cystoid spaces containing gas are also found throughout the body in cases of infection with *Bacillus aërogenes capsulatus.* The gas found in gas cysts is sometimes inflammable.

Occurrence.—The occurrence of cysts in the human body is very widespread. They may be found in practically every organ and tissue. The most important distribution is as follows:

*Fetus.*—Small cysts in the amnion are occasionally found. They are the result of a myxomatous hyperplasia of the mesenchyma. They are small and without clinical significance. Small cysts of this membrane lined with epithelial-like cells have also been described and called dermoids, but their exact nature is unknown. Cystic change of the chorionic villi due to a myxomatous degeneration of the villous stroma is relatively common. It may affect the chorion as a whole or be limited to single villi (bladder-mole, grape-mole, etc.). Larger cysts of the chorion have been observed in a few cases. These may have their origin in the liquefaction of placental infarcts, or they may arise from disturbances in the development of the chorion and amnion. Retention and degeneration cysts may be formed in the internal organs of the fetus, especially in the liver and kidneys. Their etiology is obscure; they are in part explained by errors of development and in part by inflammatory processes occurring in intrauterine life.

*Bones.*—The cysts most commonly found in bones are of the nature of degeneration or necrotic cysts. They occur chiefly in osteomalacia and in the osteoporosis of old age, arising from the liquefaction of the marrow, and may reach such a large size that only the outer shell of the bone is preserved. The cyst contents may be clear, cloudy, or hemorrhagic, frequently containing much liquid fat. As a rule they possess a connective-tissue capsule, and from this capsule there occurs sometimes in osteomalacia a reparative proliferation of connective tissue. Degeneration cysts

are also of very frequent occurrence in tumors arising either from the periosteum or from the medulla but more often in those from the latter. They occur most frequently in the myxoma and sarcoma of bones, but also in synchondromata and fibromata as well as in metastatic carcinoma of bone. A cystoid cavity, often multilocular, usually results from the degeneration of these tumors, the wall of the cavity consisting of tumor tissue or bone. Not infrequently there is a new formation of bone in the wall of the cyst. Cystic dilatation of the antrum of Highmore occurs rarely. Proliferating cysts are seen rarely in the jaws; they arise from the tooth sacs (alveolar cysts). Echinococcus cysts may occur, usually in the long bones, pelvis, skull, vertebræ, and phalanges. They may occur as exogenous cysts beneath the periosteum, and a few cases have been reported in which the surface of the femur and tibia was completely covered with such cysts. Through pressure the bone atrophies and disappears, or necrosis takes place, thus often leading to spontaneous fracture. When originating in the medulla echinococcus cysts resemble myelogenous tumors for which they are usually mistaken. The cysticercus is only very rarely found in bone.

*Muscle.*—Necrotic cysts occur in old extravasations and in myxomata and sarcomata arising from the intermuscular connective tissue. Echinococcus cysts are rare; those produced by the cysticercus are more frequently found. Cysts of small size are formed by *Trichinella spiralis.*

*Tendons, Bursæ.*—Cysts found in these structures are usually lined with endothelium (hydrops, hygroma, ganglion, etc.). Necrotic cysts may arise from the liquefaction of hematoma contents. These are likewise usually lined with endothelium.

*Nervous System.*—Cysts lined with endothelium are found rarely in the dura (dural hygroma). Echinococcus and cysticercus cysts are both found in the meninges, the latter as solitary cysts of the size of a pea or in large lobulated cysts containing grape-like clusters of daughter cysts both inside and outside (C. racemosus). These cysts are for the greater part sterile, but some may contain a single scolex. About them extensive proliferation may be excited. Echinococcus cysts are rare in the brain substance while cysticerci are of relatively frequent occurrence. The most common cysts of the brain substance are those produced by degeneration of infarctions or extravasations. As a rule these possess no independent wall; they are filled with a fluid similar to the cerebrospinal. Necrotic cysts are also common in brain tumors, especially in the glioma. Cerebellar cysts may arise from diverticula of the fourth ventricle. Cysts are very frequently seen in the choroid plexus; they vary in size from a pea to a cherry. The cyst wall consists of delicate connective tissue containing fine vessels, is covered outside with polygonal epithelium, and is lined with endothelium. Delicate fibers of connective tissue containing vessels not infrequently are stretched across the cyst cavity. Similar cysts are also found in the pineal gland and hypophysis, those of the latter being sometimes lined with ciliated columnar cells. Their significance is unknown. Cysts of the brain and its membranes may also arise from errors of development (encephalocele, meningoencephalocele, etc.). Similar cysts are found also in the spinal cord (spina bifida, etc.). Cystic degeneration of Pacinian corpuscles has been observed by the writer. (See above, Ependymal cysts.)

*Special-sense Organs.*—With the exception of insignificant retention cysts, cysts are not found in the ear, although hemorrhagic cysts occur not rarely in the pinnæ. Cysticercus cysts may occur in the eye. Small cysts lined with stratified epithelium are found in the iris after injuries to the cornea and have been explained as being due to implantations of corneal epithelium. Small dermoid cysts have been observed in the cornea. The writer has observed retention cysts in an adenoma of the lacrymal gland, and cystic dilatation of the lacrymal duct and gland (dacryops) is not rare.

*Skin.*—The most common cysts of the skin are the retention cysts of the hair follicles and sebaceous glands (atheroma, sebaceous cyst, etc.). They occur most frequently in the scalp, skin of the neck, and forehead. Dermoids are found in the subcutaneous tissue, as are also echinococcus and cysticercus cysts. Small miliary cysts of the sweat ducts occur under certain conditions, and in many of the diseases peculiar to the skin cyst-like spaces of varying nature may arise. Cystic dilatations of remains of the branchial clefts may be found beneath the skin in the neck. In rare cases cysts arising from the omphalomesenteric duct may be formed in the abdominal wall.

*Alimentary Tract.*—Retention cysts of the mucous glands may occur in any part of the mucosa of this tract from the lips to the anus. Small ones may be formed in acute catarrhal processes, larger ones in chronic catarrhs, dysentery, etc. Small cysts embedded in the muscle of the tongue are occasionally found. The ducts of the salivary glands may become obstructed and thus give rise to cystic dilatation; the tumor usually presenting itself in the floor of the mouth, beneath the tongue (ranula). Dermoids are also found in the tongue and mouth. Cysts arising from the tooth follicles may reach the size of a hen's egg (alveolar cysts). Cystic dilatations of the vermiform appendix may occur. Cysts connected with the intestine may arise from remains of the omphalomesenteric duct.

*Respiratory Tract.*—Retention cysts of the mucous glands are found on the epiglottis, and in the mucosa of the larynx and trachea, more rarely in the bronchi. Rarely air cysts may be formed in these glands as the result of air being forced into them under high pressure. These may press outward between the trachea and the esophagus. Dermoids have been observed in the lungs, but it is probable that these arose in the mediastinum. Echinococcus cysts of the lungs are very rare. Air cysts arise from the formation of emphysematous diverticula and their subsequent shutting off.

*Thyroid.*—Cystic degeneration of the thyroid through increased formation of colloid is of very frequent occurrence (struma cystica). These cysts contain colloid of varying color and consistence. Hyaline change and calcification are of frequent occurrence in the walls of these cysts, and the formation of true bone has also been observed in them (struma cystica ossea). Similar cysts in the thyroid region arise in accessory thyroids. The writer has observed in a case of acromegaly a cystic change in the parathyroids. The cysts varied in size from a pinhead to a pea, and contained an albuminous fluid which bore no resemblance to colloid.

*Heart.*—Both cysticercus and echinococcus cysts have been observed in the pericardium. Degeneration cysts in new growths are also found here. In adhesive pericarditis cyst-like cavities may be formed between the adhesions, and these may become lined with hypertrophic endothelium presenting a gland-like appearance. In the heart muscle itself both the echinococcus and the cysticercus have been found.

*Spleen.*—Large necrotic cysts may follow anemic infarction. Echinococcus cysts have also been observed in this organ, more rarely the cysticercus. Small cysts containing serous fluid are found rarely near the capsule. They are lined with endothelium and are supposed to be due to peritoneal inclusions.

*Liver.*—Cyst-like dilatation of the gall-bladder is not uncommon from obstruction of the duct by gall stones. Retention cysts of the smaller bile ducts

in the liver substance are not rare. These usually possess a thin wall and contain a clear or bile-stained serous fluid; in other cases the walls are thick and the contents made up of thick bile, fat, and cholesterin. As a rule the cysts are lined with a low columnar or flattened epithelium derived from that of the bile ducts. All gradations of size between these small cysts and those attaining the size of a fetal head may be found. In some cases the number is so great that but little of the liver parenchyma is left (cystic degeneration of liver). Associated with this a similar condition may be found in the kidneys. Such cases are very frequently of congenital origin, and are most probably to be explained by some disturbance of development during fetal life. Solitary cysts containing clear fluid and lined with ciliated cells occur rarely in the liver parenchyma. Their significance is unknown. The most important cysts of the liver are those caused by the echinococcus; they occur more frequently in this organ than in any other part of the body. Necrotic cysts occur in tumors of the liver, especially in secondary sarcomata.

*Pancreas.*—Cysts of the organ may arise from obstruction of the pancreatic duct (ranula pancreatica). Degeneration cysts following necrosis, gangrene, hemorrhage, etc., are not uncommon. In other cases pancreatic cysts may arise from disturbances of development. They may reach a very large size and as a rule show a tendency to proliferation. From such cysts multilocular cystomata may develop.

*Adrenals.*—In the hyperplasias of these organs—known as adrenal struma—degeneration cysts occur after the growth has reached a certain degree of development. Necrosis of the central portion of the growth takes place so that the only living tumor tissue is found as a narrow zone just beneath the capsule. Softening develops in the necrosed portion and in time a cyst of large size may result. The contents are usually reddish or brown in color and of a pultaceous consistence. Rupture of the cyst may take place. Such cysts may form in the accessory adrenal tissue found in and about the kidneys, in the liver, etc., and in adrenals of Marchand found in the broad ligament and near the testis. Adrenal tissue has been found in the walls of cysts of the broad ligament.

*Kidneys.*—After the ovaries the kidneys are the organs in which cysts are found more frequently than in any other part of the body. They may be solitary or numerous, large or small; they lie usually just beneath the fibrous capsule, having a thin wall and containing a clear yellowish fluid (so-called urine cysts). They are found also throughout the kidney substance, and may show all gradations of size from a pinhead to a hen's egg. They are lined with flattened epithelium which in the older cysts may have undergone degeneration. In these the contents may resemble colloid, and are not infrequently mixed with blood pigment. These cysts are retention cysts of the glomeruli and tubules, and are most commonly found in chronic nephritis, about infarct scars, and in all conditions of the kidney in which the connective tissue is increased. A few of these simple retention cysts are found in the kidneys of almost every individual after the age of forty. Congenital cysts of the kidney are found in the new-born in whom they sometimes reach a very large size and interfere with delivery. Extensive cystic degeneration of the kidneys, usually in association with a similar process in the liver, occurs in adults and is probably the result of some congenital anomaly. The organs may appear as if honeycombed, very little of the secreting structure being left. Cystic degeneration of sarcomatous tumors of the kidneys may occur and may be mistaken clinically for ovarian cysts. Proliferation cysts and dermoids have been described. Both cysticercus and echinococcus cysts occur rarely, the latter sometimes reaching a very great size.

*Peritoneum.*—Small cysts with serous contents are frequently found in the peritoneum, especially in the neighborhood of the female genital organs. They are found also in inflammatory adhesions, but may develop without preceding inflammation. In certain cases the entire peritoneum may be covered with small cysts varying in size from a pea to a walnut, many of them being attached to slender pedicles. They possess a delicate wall, and their contents may be either serous or chylous. They are partly lymph cysts arising from dilated lymph vessels, and partly of the nature of cystic lymphangiomata. Serous cysts and gas cysts similar to those of the vagina have been observed in the serosa of the intestines and in peritoneal adhesions. The cysticercus forms harmless cysts in the peritoneal cavity, but those of the echinococcus may reach a very large size.

*Female Genital Tract.*—Cystic dilatations of constricted portions of the canal of Nuck sometimes occur. These may present themselves in the labia majora as large cysts lined with endothelium derived from the peritoneum. Atheromata and lymphangiectatic cysts are very common in the vulva. Retention cysts are not infrequently seen in the glands of Bartholin and may reach the size of a goose egg. Smaller cysts with serous or mucous contents are sometimes found in the hymen and around the entrance to the vagina. The gas cysts of the vagina have been described above. Retention cysts are extremely common in the mucous glands of the cervix (ovula Nabothi), especially in cases of ectropion and erosion following laceration of the cervix. They are almost constantly present in women past the menopause. These cysts show an especial tendency toward proliferation and from them cystadenomata not infrequently arise. Retention cysts of the glands of the endometrium are very common, especially in chronic endometritis in which disease the cysts may be so large and numerous as to warrant the name of cystic endometritis. A tendency to proliferation is observed here also. Necrotic cysts occur with great frequency in the uterine myofibromata and sarcomata. Cystic dilatation of the tubes may occur as a result of obstruction or constriction (hydrops tubæ cysticus). By confluent growth with ovarian cysts tuboovarian cysts may be formed. The small hydatid cysts occurring almost constantly near the fimbriæ are without significance except when they reach a large size or show a tendency to proliferation. On the surface of the tubes and broad ligament there are occasionally seen in women past the menopause large numbers of small colloid cysts which have been thought to be degenerating ova. The cysts of the ovary and parovarium are of endless variety: degeneration cysts of Graafian follicle (hydrops folliculi Graafianii) and corpus luteum, follicular cysts, proliferation cysts, dermoids, cystic teratomata, etc. The so-called "kleincystische" (small-cyst) degeneration of the ovary is probably to be looked upon as an early ripening of a large number of follicles, a form of follicular hypertrophy. In some cases the dilatation of the follicles is the result of inflammatory processes. Cysts in the broad ligament may arise from the remains of Müller's ducts or from the adrenal tissue (Marchand's adrenals) which may be found there. The cysts of Kobelt are dilatations of portions of the parovarium. Echinococcus cysts arising from the ovary and uterus have been observed.

*Male Genital Tract.*—Cysts are very common in the head of the epididymis or its neighborhood. They may have a milky content (galactocele) or may contain spermatozoa (spermatocele). The wall of such cysts may be lined with ciliated, simple columnar, or flattened epithelium. They occur almost constantly

in old age without significance, but in youth they are usually the result of inflammation and may be numerous and reach a large size. Occasionally they arise without preceding inflammation. They arise from the vasa aberrantia. The so-called hydatids of Morgagni are small and practically without significance. Cystic dilatation of the tubules of the body of the testis may be caused by new growths. Necrotic cysts are also found in primary tumors of the testis. Dermoid cysts and cystic teratomata are relatively common while the parasite cysts are but rarely found. Cystic dilatation of the spermatic cord and seminal vesicles is not uncommon. Retention cysts are found in the prostate and urethral glands. Cysts may also arise in the neighborhood of the prostate from the remains of Müller's ducts. Small cysts are occasionally seen in the prepuce and scrotum.

*Mammary Gland.*—Retention cysts occur in this organ very frequently. According to the character of their contents they are called "milk cysts," "butter cysts," "soap cysts," galactocele, etc. Proliferation cysts are also very common and from them the various forms of cystofibromata arise. Necrotic cysts occur in case of malignant tumor. Cystic degeneration of the gland within certain limits occurs as a senile change.

Cysts may be found at any age but are most common in late adult life and old age. Within certain limits cyst formation in the kidneys, ovaries, testicles, uterus, etc., may be regarded as a part of the physiological atrophy due to senility. The cysts found in early life are most frequently those due to congenital errors of development. Such cysts in connection with the genital tract may at puberty show marked tendency to proliferation and for this reason first manifest themselves at this time. The menopause is also a period of active cyst formation in the female genital tract. As a rule the growth of cysts is slow, but in some cases the rapid and excessive formation of secretions or exudations within the cyst may lead within a short time to the formation of a cyst of enormous proportions. The degenerative changes so frequently occurring in the walls of cysts very soon lead to marked changes both in and around the cyst. Through the proliferation of the wall following inflammation or through solidification and organization of the cyst contents many cysts become obliterated. This fact is sometimes taken advantage of by the surgeon, who, by the injection of some irritating fluid into the cyst cavity, produces an inflammation within the cyst wall in the hope that the resulting proliferation may obliterate the cyst.

The true cysts are benign growths in that they do not produce metastases. The proliferation cysts alone are allied to the cystic neoplasms, and since the latter so frequently arise from them they may be regarded as intermediate forms between the cysts and cystomata. Cysts become malignant by virtue of size and position, and the secondary changes which they undergo. Cystic degeneration of the placenta may lead to abortion. Cysts of the meninges and brain may produce very serious disturbances on the part of the nervous system. Large atheromata of the scalp may cause a pressure atrophy of the underlying portions of the cranium. Cysts of the neck and respiratory tract may interfere seriously with respiration and deglutition. Cysts of the internal organs when of very large size may produce fatal results through pressure or rupture. Echinococcus cysts in the heart may give rise to extensive metastases or may cause sudden death through rupture of the heart wall. Rupture of cysts into any of the body cavities may give rise to widespread inflammations of serous surfaces. This occurs most frequently in the case of large ovarian cysts. Occasionally the mucous contents of these cysts may be spread in a thick layer over the entire peritoneum, becoming partly organized (pseudomyxoma of peritoneum). Cysts of the liver, pancreas, and kidneys may through pressure cause complete atrophy of the parenchyma of the organ. Spontaneous fracture may follow the formation of bone cysts.

Diagnosis.—Only very general points can be given as to the diagnosis of cysts. As a rule they form circumscribed tumors, more or less movable, elastic, and fluctuating. Aspiration of the cyst contents and their chemical and microscopical examination often yield important aid in the differential diagnosis. This is especially true in the case of parasite and degeneration cysts. The location, manner of origin, character of cyst wall and lining, rate of growth, etc., are all points of diagnostic importance.

Symptomatology and Treatment.—The *symptomatology* of cysts in general is too large and complex to admit of definite generalizations, and only very general statements can be made in regard to their *treatment.* This is almost wholly along surgical lines, and consists either in the removal of the cyst as a whole or in its obliteration through aspiration and the excitation of reparative processes.

Aldred Scott Warthin.

**Cytase.**—This is one of the terms which has been applied to the complement or alexin. The complement has quite definitely been shown to act as a ferment and as its activity is directed wholly against cells of one kind or another this name has been proposed. For a discussion of the complement the reader is referred to the article with that title.

Ralph G. Stillman.

**Cytodiagnosis.**—By cytodiagnosis (κύτος, a cell; διάγνωσις, knowledge by means of) is meant the detection of pathological processes by means of changes in the morphology and numerical value (relative and absolute) of the cells found in the transudates and exudates from the normal and abnormal cavities of the body.

Exudates were first studied in respect to their cellular characteristics by Boettcher[1] in 1867 and not again authoritatively till 1882 when Ehrlich[2] reported upon pleural exudates. Cytodiagnosis as a routine clinical procedure had its beginning with the study of the cerebrospinal fluid as obtained by Quincke's lumbar puncture technique. Councilman, Mallory, Wright, Bernheim, and Moser, all in 1897 and 1898, contributed especially to the technique of fixing and staining fluids for cell study. In 1900 Widal and Ravaut reported upon numerous observations made by them and described the technique in detail. Since this date many clinical reports, monographs, and books have appeared under the title "Cytodiagnosis" and the procedure has taken its place among those recognized as reliable, in gathering clinical evidence. As is usually the case with a newly discovered avenue of investigation, too much was claimed for the cell findings at first and the recent writings give a much more conservative estimate of this study, emphasizing especially the importance of repeated examinations with comparison of the findings at various stages of disease processes. Disease processes are rarely stationary and cellular response varies with the varying stages and phases of bacterial invasion, or in the case of mechanically produced fluid the features change with varying pressures.

In the whole field of clinical pathology the necessity for repeated examinations with close comparison of the different findings, cannot be urged too strongly. By cytological study of body fluids, valuable *contributory* evidence is obtained, but it rarely offers pathognomonic features. In order to draw correct conclusions the clinician must consider also the other characteristics of the exudate or transudate.

The proper study of such fluids then comprises:

1. The physical properties (amount, pressure, specific gravity, color, odor, transparency, consistency, coagulability, amount of sediment, etc.).

2. The chemical features (reaction, albumin, serumglobulin, mucin, sugar, urea, sarcolactic, lactic, and succinic acids, allantoin, inosite, etc.).

3. The bacteriological characteristics (studied by culture, fixation, and animal inoculation).

4. Cytological findings (cell content and morphology).

Occasionally one arrives at a diagnosis before this list is exhausted, but conclusions should be cautiously drawn when portions only of these investigations have been carried out. The bacteriological findings *when positive* offer conclusive evidence and can be considered to outrank the others even when these seem to present evidence in conflict with clinical experience. For example—a polynucleosis with tubercle bacilli does not detract in any way from the diagnosis of tuberculosis. The finding of the micrococcus of Weichselbaum in the spinal fluid clinches the diagnosis of cerebrospinal meningitis irrespective of any other findings.

Cytodiagnosis, because described here under a separate heading, should not be considered as a clinical method by itself. In the division of labor in preparing a work like the REFERENCE HANDBOOK, cytodiagnosis is considered separately; clinically the evidence obtained by this method must be weighed with the other findings mentioned above.

The technique of procuring these fluids for examination is described in this work under various headings. For example: Cerebrospinal fluid, see *Lumbar Puncture*, Pleural and Abdominal fluids, see *Paracentesis Thoracis* and *Paracentesis Abdominis*, etc.

The fluids which may be examined cytologically are—

1. Cerebrospinal fluid...brain and spinal cavities.
2. Pleural fluid .....pleural cavity.
3. Pericardial fluid.....pericardial cavity.
4. Peritoneal fluid.....abdominal cavity.
5. Synovial fluid.....joint cavity.
6. Cyst fluids.....cysts.
7. Hydrocele.....tunica vaginalis.

*Note.*—Material from abscess cavities and that from areas of parasite invasion (ameba, etc.) yields features which have little to do with cellular or chemical characteristics.

The quantity and quality of these fluids are altered mainly by the two following factors:

1. *Mechanical*, in which the fluid transudes under pressure into the cavity. In such there is no inflammatory agent exciting chemotactic response of the cells; there is therefore no marked cellular increase observed, the abnormality being an increase in quantity (*Transudates*).

2. *Inflammatory*, in which the fluid exudes as a result of excitation by some organism which has a chemotactic effect upon certain cells which in consequence are found in increased numbers (*Exudates*).

*Treatment of Fluid for Examination.*—Fluids should be centrifuged before clotting occurs or treated in such a way as to obtain as many as possible of the cellular elements. When a clot has formed the cells may be separated by shaking the clot in a flask containing several smooth glass particles, similar to those in the bulb of a Thoma Zeiss blood mixer. Wolf recommends the addition of citrate of sodium to prevent clotting if immediate examination is not possible. The amount to be employed for examination is preferably 25 c.c., though it is possible to determine the cellular characteristics of 1 c.c. of fluid. An electric centrifuge revolving at about 3000 to 5000 revolutions to the minute for five minutes, will precipitate practically all the cells. A hand or water centrifuge will of course serve, but not so satisfactorily as the rapidly revolving machine. If examination cannot be carried out at once, the fluid should be kept on ice. After twenty-four hours the fluid is not suitable for examination, unless preserved in sterile tubes when the cells will retain their characteristics for forty-eight hours. Sterile receivers should be used, as bacteria render the fluid unsatisfactory for examination. Such precaution furthermore makes it possible to make cultures from the fluids, a procedure of the utmost importance in practically all abnormal fluids. The supernatant fluid should now be poured off, and the tube inverted for a minute or two. The sediment shaken with a weak saline solution (0.85 per cent.) and again centrifuged. The sediment is now drawn up by a pipette or gently scraped off, and spread on a glass slide and allowed to dry in the air. The fixing may be done through a fixing stain (Wright or Jenner) or by methyl alcohol, or equal parts of alcohol and ether for twenty minutes, or by heat (115° for six to eight minutes). In routine laboratory work the flame can be used, but this requires practice, and should never be relied on in important cases. A basic (methyl blue) and acid (eosin) stain may be employed separately or the ordinary blood stains (Ehrlich's) may be used. It is possibly more satisfactory to use separate stains (eosin and hematoxylon, etc.) as the intensity of the stain can be better controlled than with the compound stain (Jenner, Wright, or Leishman). Two or three specimens each prepared with one of these stains and then compared, is the most satisfactory method. In a cytological examination the following points should be observed:

1. The presence or absence of cells (cell content).
2. The types of cells present (morphology).
3. The abundance of cells (absolute cell value).
4. The relative proportion of cells present (relative cell value).

No such beautiful picture of readily differentiable cells as is seen in a stained blood specimen is observable in even the best taken specimen of exudates from the various cavities. A degree of lysis of the cell has gone on in all such fluids with a consequent mutilation of the cells. The exudate is an abnormal fluid and the cells are in this abnormal medium. So complete is the destruction at times that a cytological examination made in an advanced stage of inflammation is almost barren of results. It is well to repeat then, that the physical, chemical, cytological, and bacteriological (and in some instances animal inoculation and complement fixation) findings must be *reckoned together* in the majority of cases, in order to arrive at a correct diagnosis. Before considering the fluids as obtained from the cavities, it will be profitable to study the cells found in all cavities as the cell response is due to a pathological process common to the system as a whole rather than peculiar to any portion of the body. The cells are:

1. Endothelial cells.
2. Lymphocytes.
3. Large mononuclear cells.
4. Polynuclear neutrophiles: leucocytes.
5. Eosinophiles.
6. Red blood cells.
7. Mast cells.
8. Cells of malignant growth (sarcoma and carcinoma).

1. *Endothelial Cells.*—These cells we found in small numbers in transudates. So few are they that several slides taken at the same time may show no cells. The transudate appears to be without cells. Later, however, and especially after several tappings, these cells may increase in number reaching as high as ninety per cent. They are derived from prolification of the serous membrane endothelium and their presence in excess is strong evidence against an inflammatory process. A non-cellular fluid, especially if constantly so, is strong evidence against an inflam-

matory exudate, and excess of endothelial cells is equally strong evidence in favor of a transudate. The presence of endothelial cells in any quantity is strong proof against tuberculosis *except* in the early stage of a tuberculous infection. By watching such a tuberculous fluid these cells will be found to disappear, to be replaced by lymphocytes to which *later* polynuclear neutrophiles may be added. The endothelial cells are about ten times the size of the red cells, have usually one nucleus, though occasionally there are two; they readily undergo degenerations, showing broken down granules and swollen protoplasm. This large cell will rarely be confused with other cells, except when fragmentation and degeneration have occurred, or when by virtue of their phagocytic power they have engulfed other cells and fragments. Under these circumstances they are to be distinguished from (*a*) carcinoma cells and (*b*) polynuclear neutrophiles.

(*a*) Carcinoma cell. Perhaps the most distinctive feature about the carcinoma cells is their dissimilarity; dissimilar in staining intensity and morphology. The cell body contains many different particles, "inclusions," fat cells, and vacuoles. The nucleus may be simple, double, or multiple and shows mitotic figures. The endothelial cells on the contrary do not show this wide diversity in appearance. They are not in any sense uniform but it will be possible in fluids examined promptly after withdrawal to find a greater uniformity in cell features. The nucleus of the endothelial cells may be single or double, rarely multiple, shows no mitosis and is usually oval with sharp margins. The cell body may be vacuolated. When much fragmentation and phagocytosis has taken place it is very difficult to differentiate the contents of the cell body from the particles found in the cancer cells. It is in long standing effusions that cell damage takes place, and these cases present great difficulty in cell differentiation. In such cases, if carcinoma be present, carcinoma masses sometimes can be found and this offers conclusive evidence. The differentiation under most circumstances is difficult, and it may be well to repeat that the most reliable feature is the greater diversity in appearance one from the other of the cancer cells, and the relatively greater tendency to similarity of the endothelial cells.

(*b*) The polynuclear neutrophile may be engulfed by the endothelial cell when the appearance of neutrophiles will be taken on by the endothelial cell. This can usually be detected by close observation.

2. *Lymphocyte.*—This may be considered as the cell which brought cytodiagnosis into clinical recognition. Its association with tuberculous processes gained for it an exaggerated diagnostic importance which subsequent investigation has modified. It is, however, the cell most responsive to the tuberculous invasion, and if studied in conjunction with other clinical findings will in many instances prove a most important index of tuberculous processes. As the tuberculous infection progresses the lymphocytes may be associated with or replaced by polynuclear neutrophiles and this change in cellular content is the most important point to be on the alert for. The polynuclear neutrophile may precede also the lymphocytosis in tuberculous infections. Too much emphasis cannot be placed upon the importance of watching these changes in cell sequence. Isolated observation or examinations at great intervals may yield information confusing rather than helpful. These cells are found in excess in the cerebrospinal fluid of tuberculous meningitis *after the acute stage.* They are sometimes replaced by polynuclear neutrophiles in the advanced stage and during recovery. They are found in excess in general paralysis of the insane (lues), tabes dorsalis, cerebrospinal syphilis —excess has been reported in intracranial tumors, herpes zoster, mumps, and chronic alcoholism, though these latter still need confirmatory evidence. Broken-down and fragmented endothelial cells and polynuclear neutrophiles may be mistaken for lymphocyte. These together with connective tissue masses may be classed under pseudolymphocytes.

3. *Large Mononuclear Cells.*—The origin of these cells is in question. Marchand considers that they come from the perivascular lymphatic tissue (leucocytoid cells) while others attribute them to either connective tissue, the blood stream, or endothelial cells. Most of these cells are phagocytic, reaching great size. This phagocytic property often renders them difficult to distinguish from leucocytes, though their size and tendency to degeneration makes them in most instances differentiable from the polynuclear neutrophile. They degenerate so rapidly after the fluid is withdrawn that in order to study them examination should be made as soon as possible after withdrawal and preferably the specimen should be unstained. Their significance is almost as obscure as their origin. An excess of such cells is said to indicate a favorable prognosis in an inflammatory exudate, while their absence, in the presence of bacteria, indicates an impending suppuration. Their relation to tuberculosis is indefinite. At present perhaps the most important point about these cells it to differentiate them from polynuclear neutrophiles and other cells with which they might be confused. A knowledge of their diagnostic importance awaits further study.

4. *Polynuclear Neutrophiles.*—This is the cell most frequently associated with inflammatory invasion by a pyogenic organism. Actual pus need not have formed at the seat of the exudate; for example, the pleurisy of a pneumococcus pneumonia yields a polynuclear leucocytosis in the pleural exudate even though an empyema may never develop. It is in excess also in the *early stage* of a tuberculous pleurisy and pericarditis, and again in the late stages or during recovery.

In empyema and pyopneumothorax the polynuclear neutrophile undergoes degeneration, and the presence of much destruction indicates an advanced stage of sepsis.

5. *Eosinophile.*—Considerable diversity of opinion exists regarding this cell. That it varies in its relation and absolute value is certain, but these variations seem as yet to present no uniform features by which diagnostic conclusion can be drawn.

6. *Red Blood Cells.*—A certain number of these cells is almost always present from contamination in the technique of obtaining the fluid. Only when they are present in considerable numbers should they be regarded as clinically important. They occur in quantity in tuberculosis, carcinoma, and in the escape of blood from an aneurysm into the pleura. Excess of blood has been reported in other conditions, but these reports require further substantiating evidence.

7. *Mast Cells.*—These are found only in pathological conditions; that is, the normal cavity fluids never contain them; beyond indicating a pathological condition, they have no known clinical significance. The fluid must be examined promptly in order to see these cells.

8. *Cells of Malignant Growth* (Sarcoma and Carcinoma).—See discussion under Endothelial Cells.

The Fluids.—In considering the fluids as influenced by pathological agents the following general subdivision will be found helpful.

1. Local venous stasis—due either to local or systemic disease.

2. General venous stasis with anasarca, as occurs in renal or cardiac disease.

3. Inflammation of the serous membrane with consequent cell activity.

4. A combination of venous stasis and serous membrane inflammation.

Nos. 1 and 2 will be seen for the most part to be

without cellular features while 3 and 4 will have a pronounced cell activity (tuberculosis, cancer, sepsis, etc.).

1. *Cerebrospinal Fluid.*—Researches (Halliburton[3]) would seem to show that this is a continuous secretion of "the cubical epithelial cells which cover the choroid plexuses." The presence of cells is always an expression of a pathological process, but their absence does not indicate an absence of a pathological process. This fluid, with the exception of a few lymphocytes, is normally devoid of cellular elements.

(*a*) Abundance of red blood cells occurs with fracture of the skull and apoplexy, though this of course is not a constant finding in these conditions.

(*b*) Excess of polynuclear neutrophiles indicates an inflammatory exudate due to pneumococcus, meningococcus, gonococcus, or other pyogenic organism. The differentiation between these can be made only by cultural and other bacteriological features. In the early stage of tuberculous meningitis an increase of the polynuclears occurs. This finding, together with a negative bacteriological finding, should always be followed by several daily cytological examinations to determine if the polynucleosis persists. The cytological findings in acute cerebrospinal meningitis may be summed up as follows:

(*a*) The fluid may show no especial cellular increase. This is rarely the case.

(*b*) Polynuclear increase the rule.

(*c*) Long standing cases which are recovering may show lymphocytosis.

(*d*) Excess of lymphocytes indicates a tuberculous meningitis of an advanced stage, though occasionally polynuclears in excess are found late into the disease. Lymphocytosis is found also in general paralysis of the insane (syphilis), tabes dorsalis, and cerebrospinal syphilis. Lymphocytosis has been reported in intracranial tumors, herpes zoster, mumps, and chronic alcoholism, but the evidence is not sufficient to state this as a reliable clinical finding.

(*e*) There is no increase of cellular elements in serous meningitis.

2. *Pleural Effusions.*—*Tuberculous pleurisy* in the early stage (third or fourth day) shows a polynuclear increase which later is replaced by a lymphocytosis. Carter's series of cases, proven by autopsy or animal inoculation to be either miliary or pulmonary tuberculosis, showed a lymphocytosis varying from 90 to 100 per cent. In the later stages and during recovery polynuclear increase may again replace the lymphocytosis. *Pleural transudates* sometimes show a lymphocytosis, the significance of which is not understood. *Serous pleurisy* due to pyogenic organism (pneumococcus, streptococcus, etc.) presents almost uniformly a polynucleosis. In Carter's cases the polynuclears ranged from 67 to 92.5 per cent. When pus is about to develop, polynucleosis may be enormous. In *renal* and *cardiac pleurisy* the endothelial cells are in excess. In *cancerous pleurisy* the cancer cells can be found singly and in masses, but must be differentiated from the endothelial cell. All these cells undergo degeneration rapidly, and in their broken down and phagocytic activity resemble one another. For their characteristics and points of resemblance, reference should be made to the description of the individual cells given above.

3. *Pericardial fluids* follow the general rule regarding cell features in the pleural effusion, though these findings are not as satisfactory as in the pleural effusions.

4. *Peritoneal Fluids.*—Cytological examination of peritoneal fluids is in most cases very unsatisfactory, though the findings as given in examination of the cerebrospinal and pleural fluids have the same general diagnostic significance.

5. *Synovial (Joint) Fluids.*—These are similar to the reaction of other serous membranes but not so uniformly. In the absence of fever lymphocytosis is more apt to be present in septic infections. Lymphocytes are more common in chronic affections and cannot be considered to indicate tuberculosis with the same certainty as in affection of other serous membrane. Polynucleosis, however, is strong evidence of septic infection (gonococcus more especially). Lymphocyte increase indicates more especially a chronicity and must not be considered as indicating tuberculosis. These together with mononuclear cells are found in small number in the Charcot joint. It will be observed that the cellular findings in joint affections offer very little definite diagnostic aid. The question as to whether the joint is a primary or secondary seat of invasion frequently arises. Is the joint involved by a toxin arising from a distant focus of infection, or is there a bacterial invasion from such a distant focus, or is the joint itself the primary focus? The writer is of the opinion that joints are rarely primary foci, and if search be made the true focus can be found in many cases. The very varied bacteriological and cytological findings in joint fluids suggest this. There is as yet however no experimental work to support this. Cultural and fixation tests of the blood and careful search for foci of pus elsewhere will yield promptly evidence of a more definite nature.

6. *Cysts.*—See article, *Cysts*.

7. *Hydrocele.*—Lymphocytes are the preponderating cell in tuberculous hydrocele, but tapping and injection of iodine are said to produce an excess of this cell. Simple hydrocele is rich in endothelial cells.

C. N. B. Camac.

References.

1. Boettcher: *Virchow's Archiv*, No. 39, p. 512. See also Zabbe: "Le Cystodiagnostic," Paris, 1903.
2. Ehrlich: *Charité Annalen* 1882.
3. Halliburton: Handbook of Physiology, 1911, p. 172.

**Cytoryctes.**—A name given to certain parasitic inclusions whose position among protozoans is still uncertain. *C. variolæ* is present in the skin of smallpox patients. See *Protozoa*.

A. S. P.

**Cystosine,** $HN{-}CNH_2$, $O{=}C\ \ CH$, $N{=}CH$

(6 amino-2 oxy pyrimidine) belongs to the pyrimidine bases which are closely related to the purine bases. It is a derivative of various nucleic acids of animal origin.

F. P. U.

**Cytotoxin.**—Animals treated with heterologous animal cells develop antibodies which have a specific solvent action on these cells. For instance, a goat serum obtained from an animal which has been injected with the liver cells of a rabbit, will have an injurious action on all the cells of the rabbit, but this action will be most marked on the liver cells and less so on the cells of the spleen or kidney. It will have little or no action on the cells of other animals such as the liver cells of the guinea-pig. When such a preparation is examined under the microscope it is seen that complete lysis is not obtained, so that this action is called cytotoxic rather than cytolytic. An exception to this is seen in the case of the hemolysins which belong to this group of antibodies and yet usually exhibit complete lysis. Since it is impossible completely to free a preparation of cells from an animal organ, from blood or connective-tissue cells, it is natural that all cytolytic sera should have a hemolytic action and that they should none of them be absolutely specific. It is interesting to note in this connec-

tion that a serum prepared by the injection of the crystalline lens of any animal shows only tissue specificity, that is, it has a lytic power for the cells of the crystalline lens of any animal. The lack of specificity in cytolytic sera is thought to be due to the fact that in the body cells there are widespread common group characteristics and only a very few groups of a specific nature. For a discussion of the relation of cytotoxins to other immune bodies the reader is referred to the article on *immunity*.

RALPH G. STILLMAN.

**Czermak, Johann Nepomuk.**—Born in Prague, Bohemia, June 17, 1828. After studying medicine in various places—Prague, Vienna, Breslau, and Würzburg—he received the degree of Doctor of Medicine from the University of his native city. In 1855 he was Professor of Physiology in Graz, Austria; in the following year he occupied the same chair in the University of Cracow; and then, during the years 1858–1860, he taught in Budapest, Hungary. Resigning his position in the latter university he returned to Prague and prosecuted his physiological researches in his own private institute. From 1865 to 1870 he was Professor of Physiology in Jena, and during the latter year he went to Leipzig, in which university he held the position of Extraordinary Professor up to the time of his death (September 17, 1873) from long-standing diabetes mellitus.

Czermak, who was endowed with a strongly marked inventive type of mind, and who owned in Leipzig a completely equipped private laboratory, succeeded in so modifying Garcia's laryngoscopic mirror as to render it serviceable for ordinary clinical examinations of the larynx. He thus gained the reputation of being the author or founder of modern laryngoscopy. (Pagel.) A. H. B.

**Dabney, William Cecil.**—Born in Albemarle County, Virginia, on July 4, 1849. He received the degree of Doctor of Medicine from the University of Virginia in 1868. He practised his profession in Charlottesville, Va., and was for some time Professor of Obstetrics and the Practice of Medicine in the University of Virginia. He died in Charlottesville on August 20, 1894.

Among his published writings the following deserve to be mentioned: "Nitrite of Amyl as an Antidote to Chloroform"; "Extirpation of Kidney for Renal Calculus"; "Physiological and Pathological Effects of Excessive Soil Moisture"; and "Medical Chemistry." For the latter essay he was awarded the Boylston Prize. A. H. B.

**Da Costa, Jacob M.**—Born on the Island of St. Thomas, West Indies, February 7, 1833. He was educated in Germany, and received the degree of Doctor of Medicine from the Jefferson Medical College, Philadelphia, Pa., in 1852. After graduation he went abroad for two years, and then, upon his return to this country, began practising in Philadelphia. While conducting a general practice he devoted himself more particularly to the study of diseases of the heart and lungs. He held for some time the position of Attending Physician at the Episcopal Hospital, and subsequently he was appointed to fill the same position, first in the Philadelphia and then in the Pennsylvania Hospital. In 1864 he received the appointment of Lecturer on Clinical Medicine at the Jefferson Medical College, and in 1872 he was given the professorship of the Theory and Practice of Medicine in the same institution. He died on October 11, 1900.

For many years, during the second half of the nineteenth century, Dr. Da Costa ranked very high as an authority on physical diagnosis. His published work on this subject, entitled "Medical Diagnosis, with Special Reference to Practical Medicine," was first issued in 1864, and passed through a number of editions during the following years. Dr. Da Costa was also highly esteemed as a clinical teacher.

A. H. B.

**Dactylitis.**—See *Hands and Fingers, Deformities of.*

**Dalton, John Call.**—Born in Chelmsford, Mass., February 2, 1825. He evinced a preference for the study of medicine at an early age, and devoted himself assiduously to it in Harvard University, from which institution he was graduated in medicine in 1847. He developed a strong liking for literary work, coupled with a taste for physiology, and in 1851 attained considerable celebrity by an original essay on the "Corpus Luteum," which was written in competition for the annual prize offered by the American Medical Association. The reputation acquired by this effort led to Dr. Dalton's appointment as Professor in the Medical Department of the University of Buffalo, where he remained until 1854, when he accepted a similar professorship in the Vermont Medical College at Woodstock. It is related of him that he was the first professor in the country to teach physiology with illustrations by vivisection. From Vermont, Dr. Dalton removed to the Long Island College Hospital, in 1859, where he remained for two years as Professor of Physiology. He had previously delivered a course of lectures on physiology in the College of Physicians and Surgeons in New York City, and in 1855 he was elected Professor of Physiology in the last-named college, a post which he continued to hold until 1883, when he resigned it to accept the presidency of the institution. At the outbreak of the Civil War he went south with the Seventh Regiment in 1861, being appointed Brigade Surgeon of Volunteers. He resigned in March, 1864, and returned to New York to resume his professional duties in the College of Physicians and Surgeons. He died February 12, 1889.

Among Dr. Dalton's most important physiological publications, may be named the following, which were printed in book form: "A Treatise on Human Physiology;" "A Treatise on Physiology and Hygiene for Schools, Families, and Colleges;" "The Experimental Method of Medicine;" "Doctrines of the Circulation," and "Topographical Anatomy of the Brain." His contributions to periodical medical literature were very numerous. T.L.S.

**Daltonism.**—Color blindness. See *Color Perception.*

**Damiana.**—The leaves of several Mexican and Central American species of Turnera, especially *T. diffusa* Willd., not all of them as yet determined, perhaps not even described. The drug contains a considerable percentage of volatile oil and resin, with some tannin and an amaroid. It is therefore an aromatic bitter. That it may have some special properties in this class appears not unlikely. The unprofessional and disgusting methods of its exploitation and use have naturally repelled the interest of investigators, so that it has not fared well at their hands. Its popular use as an aphrodisiac does not appear to be justified. The dose is gr. xv.–lx. (1.0–4.0).

HENRY H. RUSBY.

**Dammar Resin.**—*Resina Dammara.* A resin obtained from several species of Shorea (Fam. *Pinaceæ*), growing in the East Indies.

These trees are large, straight-trunked, handsome firs, from whose branches an abundance of turpentine exudes, both spontaneously and upon incision. It dries rapidly, and hardens into the tears of commerce.

Dammar comes in fine, hard, transparent, pale yellow, or nearly white, odorless tears, of irregular shape and size, but often large. It is brittle, breaking with a brilliant, conchoidal fracture, but softens

slightly in the hand, and melts at about 120° C. Soluble in chloroform, ether, carbon disulphide, fats, and oils, but not entirely so in cold alcohol or in benzin.

This resin possesses no medicinal properties and is employed wholly for mechanical purposes.

H. H. Rusby.

**Dandelion.**—See *Taraxacum.*

**Danielssen, Daniel Cornelius.**—Born at Bergen, in Norway, on July 4, 1815. He was an apothecary for some time, and then studied medicine at Christiania. He settled in Bergen in 1839, and began at once, in St. George's Hospital, his researches into the nature and treatment of leprosy. His great treatise on this disease ("Om Spédalskhed," Christiania, 1847, with atlas) was translated into French and published under the title: "Traité de la spédalskhed ou éléphantiasis des Grecs." Danielssen, whose death occurred on July 13, 1894, will always be known as one of the greatest authorities on leprosy. A bronze tablet in his honor has been placed in the Lungegaards-Hospital, in Bergen, in which institution he worked so successfully for many years.

A. H. B.

**Daremberg, Charles Victor.**—Born at Dijon, France, in 1816. He received the degree of Doctor of Medicine at Paris in 1841, his graduating thesis being entitled: "Exposition des connaissances de Galien sur l'anatomie, la physiologie et la pathologie du systême nerveux." After practising medicine for a short time he was chosen Librarian, first (1846) of the Academy of Medicine, and afterward (1849) of the Mazarine Library. In 1871, when the Faculty of Medicine of Paris reestablished the Chair of History of Medicine and Surgery, Daremberg was chosen to fill the position. He died October 24, 1872, at his country residence at Mesnil-le-Roy. After his death the Academy of Medicine of Paris purchased his splendid library.

Of his numerous and scholarly contributions to medical literature it will be practicable to mention here only a few: "Traité sur le pouls, attribué à Rufus d'Ephèse, etc.," Paris, 1848; "Notices et extraits des manuscrits médicaux grecs, latins et français des principales bibliothèques d'Europe," 1853; "La Médecine; Histoire et Doctrine," 2nd edition, 1865; and "De l'état de la médecine entre Homère et Hippocrate, etc.," 1869. A. H. B.

**Darwin, Charles Robert.**—The most distinguished English naturalist of the nineteenth century, and the author of the famous work entitled "The Origin of Species." He was born at Shrewsbury, the county town of Shropshire, on February 12, 1809. At the age of sixteen he went to Edinburgh to prepare for the medical profession; but, after two sessions, his father, Dr. Robert W. Darwin, realized that his son was not fitted by nature for this calling, and in 1828 sent him to Cambridge with the idea that he should become a clergyman. He took his degree in 1831, and shortly afterward joined the *Beagle* which was about to start on a surveying expedition. His official position on board the vessel was that of naturalist; and during the long voyage, which lasted until October 2, 1836, and carried him to very many places in South America, New Zealand, Australia, and the islands of the Atlantic and Pacific Oceans, he gathered an immense amount of material which served as the basis for the various monographs which he afterward wrote, and especially for the great treatise which he published in 1859, and which in its final form bore the title: "On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life." In 1868 he published a second work of considerable importance, and gave to it the title: "The Variation of Animals and Plants under Domestication." Then, during the following fourteen years, he published several monographs which all served to expand or to make more clear the ideas which he had put forth in the earlier and larger treatises. He died at his home in Down, April 19, 1882, and he was buried in Westminister Abbey on the 26th.

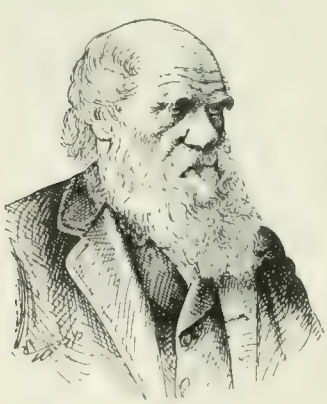


Fig. 1636.—Charles Robert Darwin.

A. H. B.

**Datura.**—See *Stramonium.*

**Davainea.**—A genus of tapeworms found in man. These parasites have a globular "head" armed with two rings of hammer-like hooks and four suckers surrounded by several rings of hooks. Two species are known: *D. madagascariensis*, in British Guiana, Bankok, Mauritius, etc., and *D. asiatica* in Aschabad, north of Persia. See *Cestoda.* A. S. P.

**Davaineinæ.**—A subfamily of tapeworms, family *Tæniidæ*, order *Cyclophyllidea*, in which both the rostellum and suckers are armed with hooks. It contains a single genus, *Davainea.* See *Cestoda.*

A. S. P.

**Daviel, Jacques.**—A French surgeon who flourished during the first half of the eighteenth century, and who is entitled to the credit of having first performed the operation of removing a cataract by extraction. He was born at La Barre, near Evreux in the present department of Eure, on August 11, 1696. He studied medicine, at first with his uncle, a practitioner at Rouen, and afterward at Paris. When the plague broke out at Marseilles he was one of the first to volunteer his services. He did his work so courageously and so intelligently during this epidemic that the authorities made him an agrégé of the corps of master surgeons and put him in charge of a galley as its surgeon-major. This gave him the right to receive a pension and, in addition, the privilege of making such disposition as he pleased of the bodies of all those who died in the hospitals of Marseilles. Thanks to the latter privilege he was able to perform a great variety of operations on the cadaver and to give public courses of instruction in anatomy and surgery. In addition to these courses, which he continued to give during a period of twenty years, he gradually developed a great reputation for skill in the treatment of eye diseases. In 1746 he settled in Paris, and during the following year he performed his first operation of removing a cataract by extraction. On January 1, 1749, he received the appointment of Surgeon-oculist to the King, and from that time onward he was frequently summoned to give advice to, or to operate upon, some member of nearly all the royal families of Europe. In the month of November, 1752, he performed 206 extraction operations, and of this number no fewer than 182 proved successful. He died Sept. 30, 1762.

Daviel was too much occupied with the practical work of his profession to do much writing; and as a consequence we possess to-day practically nothing from his pen that is of special value. His name is attached to an instrument, Daviel's spoon, used to remove the remains of a cataract after discission.

A. H. B.

**Davis, Nathan Smith.**—Born January 9, 1817, in Chenango County, N. Y. He received his medical education from the College of Physicians and Surgeons, at Fairfield, N. Y., and was given the degree of Doctor of Medicine by that institution on January 31, 1837. During the first years of his career as a practitioner of medicine he lived in Binghamton, N. Y., but in 1847 he removed to New York City. During the following winter he gave, at the College of Physicians and Surgeons in that city, the instruction in practical anatomy. In July, 1849, he was elected to the Chair of Physiology and General Pathology, in Rush Medical College, at Chicago, Ill., and accepted the position. In 1850 he was transferred to the Chair of Principles and Practice of

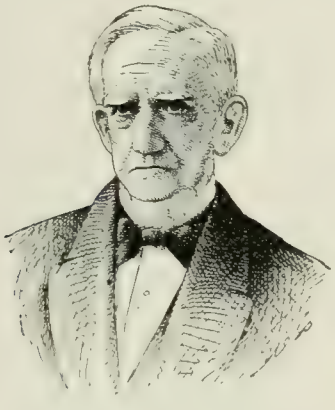


Fig. 1637.—Nathan Smith Davis.

Medicine. Nine years later (in 1859), when the Chicago Medical College was organized on the basis of a course of instruction covering three full years, Dr. Davis was called to the corresponding position in the new enterprise. His two great hobbies—if such they may be called—were the need of a higher standard of medical education and the desirability of organizing the physicians of the United States into a large central body and those of the individual States into smaller State societies, affiliated with the central association. Long before his death, which occurred on June 16, 1904, Dr. Davis had the satisfaction of witnessing the complete realization of both of the schemes which he had so much at heart and for which he had labored so earnestly and so patiently through the best years of his life. The standard of medical education in the older schools is to-day far higher than it was at the time when he first began to urge the importance of such a change; and the American Medical Association, of which he may justly be called the father, has become an organization of great magnitude and power.

Among Dr. Davis' contributions to medical literature were: "A History of Medical Education and Institutions in the United States from the First Settlement of the British Provinces to the Year 1850, with a Chapter on the Present Condition and Wants of the Profession, and the Means Necessary for Supplying those Wants" 1851; "History of the American Medical Association, from its Organization to the Year 1855;" and "Lectures on the Principles and Practice of Medicine," 2nd edition, 1887. A. H. B.

**Davos.**—(Davos-Platz, Davos-Dörfli, and Wiesen.) Davos, the best-known and most frequented "high-altitude" winter station in Europe, is composed of two villages a short distance from each other—Davos-Platz and Davos-Dörfli. It is the former, Davos-Platz, which is always meant when Davos as a health resort is referred to.

Davos first became known as a health resort for consumptives through Dr. Spengler, who was a physician there, and who communicated the fact of its immunity from phthisis to the German climatologist Meyer-Ahrens. Through the publications of the latter, Dr. Unger, a consumptive, with a friend likewise afflicted, went to Davos and was cured; and through the favorable reports and experience of Drs. Spengler and Unger the advantages of this climate for pulmonary tuberculosis began to be appreciated in Europe.

It was a radical departure from the existing ideas of a suitable climate for this disease, and it seemed a strange, not to say dangerous experiment for a consumptive to pass the winter in the snows of the Alpine Mountains. As the favorable reports of those who made the venture, however, became known, the fame of the place spread, and from eight in 1865 the number of consumptives who visited it increased yearly, until in 1890 they amounted to 1,511, of whom 89 were Americans; and now it is the most popular high-altitude resort upon the Continent, the English coming next to the Germans in numbers. In the year 1905 there were staying at Davos 20,072 persons of whom 387 were Americans. It is called a "winter resort," the climate at that season being considered the most favorable, although Dr. Turban, who conducts a large

Climate of Davos, 5,200 Feet above Sea-level.
Observations at the Davos-Platz Meteorological Station.

| | Jan. | Feb. | March. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (Fahrenheit): | | | | | | | | | | | | | |
| Average or normal | 18.70 | 23.2 | 27.1 | 35.8 | 43.9 | 50.2 | 54.7 | 53.1 | 47.7 | 38.1 | 29.3 | 20 5 | 36.7 |
| Mean of warmest | 38.7 | 42.4 | 44.2 | 56.3 | 63.9 | 73.4 | 71.0 | 71.6 | 72.7 | 58.5 | 51.8 | 43.0 | |
| Mean of coldest | 1 4 | 6.3 | −1.1 | 24.8 | 26.6 | 34.2 | 41.7 | 34.9 | 31.5 | 22.8 | 14.4 | 4.6 | |
| Av. daily range | 37.3 | 36.1 | 45.3 | 31.5 | 37.3 | 39.2 | 29.3 | 36.7 | 41.2 | 35.7 | 37.4 | 38.4 | |
| Highest or maximum | Hotte st day for 20 y rs. 82.2 ° at 1: 30 P. M. | | | | | | | | | | | | |
| Lowest or minimum | Colde st day for 20 y rs. −7. 4 at 1: 30 P. M. | | | | | | | | | | | | |
| Humidity: | | | | | | | | | | | | | |
| Av. relative | 83 | 80 | 79 | 76 | 72 | 75 | 75 | 81 | 79 | 79 | 82 | 84 | 79 |
| Absolute (in inches) | .09 | .10 | .118 | .16 | .21 | .27 | .319 | .31 | .276 | .18 | .134 | .10 | .19 |
| Precipitation: | | | | | | | | | | | | | |
| Av. in inches rain or snow | 1.8 | 2.1 | 2.0 | 2.2 | 2.2 | 4.0 | 4.9 | 4.9 | 3.7 | 2.6 | 2.2 | 2.4 | 35.3 |
| Wind: | | | | | | | | | | | | | |
| Prevailing direction | In 85 per cen t. of ob servatio ns the wind was N. E. | | | | | | | | | | | | |
| Av. hourly velocity in miles | 1.2 | 1.6 | 2.5 | 2.5 | 0 | 0 | 0 | 3.5 | 3.4 | 2 | 1.8 | .2 | 1.7 |
| Weather: | | | | | | | | | | | | | |
| Av. no. of clear days | 13 | 13 | 12 | 10 | 8 | 8 | 12 | 14 | 13 | 14 | 13 | 13 | 143 |
| Av. no. of fair days | 4 | 3 | 5 | 6 | 7 | 5 | 5 | 6 | 4 | 4 | 4 | 4 | 55 |
| Av. no. of cloudy days | 7 | 6 | 7 | 7 | 8 | 8.5 | 7 | 5.5 | 6.5 | 65.5 | 65.5 | 7 | 82.5 |

sanatorium there, told the writer that the seasons should make no difference and that a patient should remain continuously until the cure was effected. The climate is characterized by a cold, pure, dry air of great diathermancy, much sunshine and but little wind, resembling closely that of Colorado, with the important difference, however, that the daily average of sunshine in Colorado is much greater than at Davos. The snow covers the ground deeply during the winter generally from the middle of November to middle of April, but it is a dry snow.

Davos is situated in the Canton des Grisons, Switzerland, in the upper Engadine, at an elevation of 5,115 feet above sea level. The valley of Davos is about fourteen miles long, and about half a mile wide, and runs from northeast to southwest. The mountains which shut in the valley rise from 2,000 to 3,000 feet above its bed. It is protected from the north and west winds; indeed, one of the most remarkable and characteristic features of the climate of this resort is its windlessness. It possesses all the attributes of an Alpine village—long winters; a mountain torrent, the Landwasser, traversing the valley; sparse vegetation; forests of fir and larch upon the mountain sides; high sun, and low, freezing, shade temperature. The soil is sandy and dry. The snow, which lies two or more feet deep during the winter, begins to melt about the middle of March, and patients leave about the first of April. The foregoing table gives the general characteristics of climate so far as averages can do so.

The average temperature for the year is 36.7° F., and for the seasons: Winter, 20.8° F.; spring, 35.6° F.; summer, 52.7° F.; autumn 38.3° F.

The striking characteristic in the temperature, more or less common to all high-altitude resorts, is the great difference between that of the sun and that of the shade; in a moment one passes from winter to summer, or the reverse. Here is the comparison given by Richards in his article upon *Davos* in the previous edition of the HANDBOOK, quoted from Weber.

The annual rainfall and melted snowfall at Davos, as seen by the table is 35.3 inches, and for the seasons: for winter, 6.1 inches; spring, 6.4 inches; summer, 11.9 inches; autumn, 9.2 inches. The average number of cloudless days for the season from October to March, inclusive, was 78; average number of fine but not cloudless days, 24; average number of cloudy days, 40; and average number of rainy or snowy days, 40. The average number of cloudless and fine days was 102 out of a possible 182, or a little more than one-half. The average hourly velocity of the wind for four seasons is: Winter, 1.6 miles; spring 2.5 miles; summer, 3.4 miles; autumn, 2.4 miles. The prevailing direction of the wind is northeast.

Stillness of atmosphere, then, is another of the chief characteristics of the winter climate of Davos, although exceptions do occur and "bad winters," with many windy days, happen occasionally.

Owing to the fact that Davos is in a narrow valley shut in by high mountains, the length of the days is considerably shortened, especially in winter. For instance, upon January 1, the sun rises at Davos 11:03 A.M., and sets at 3 P.M., while at Denver, for comparison, it rises at 7:30 A.M., and sets at 4:37 P.M. In Colorado Springs the invalid's day in winter is given by Solly as seven hours long, while at Davos in the same season it is only about five hours long. The comparison of the amount of sunshine in Denver and Davos is given by Solly, as calculated from the weather-bureau reports and from Waters' tables, as follows:

HOURS OF ACTUAL SUNSHINE (MONTHLY MEANS).

| | Winter. | Spring. | Summer. | Autumn | Year. |
|---|---|---|---|---|---|
| Denver . . . | 188 | 242 | 290 | 243 | 240 |
| Davos-Platz. . . . | 100 | 166 | 196 | 126 | 147 |

SUN AND SHADE TEMPERATURES AT DAVOS, 1876–77 (FAHRENHEIT SCALE).

| | October. | November. | December. | January. | February. | March. | Average. |
|---|---|---|---|---|---|---|---|
| Mean maximum sun temperature.... | 133.07° | 106.12° | 109.08° | 108.30° | 111.36° | 122.32° | 115.04° |
| Mean maximum shade temperature. | 60.40 | 36.63 | 39 | 36.07 | 34.55 | 36.46 | 40.51 |
| Difference . . . | 72.67 | 69.49 | 70.08 | 72.23 | 76.81 | 85.86 | 74.53 |

Although the average winter temperature is so low (namely, 20.8° F.), yet in the sunshine one can sit in the open air with comfort or even be too warm. Moreover, in the shade and in the absence of sunshine, says Weber, low temperature produces very little discomfort at Davos as compared with that experienced in level countries, partly on account of the dryness of the air, partly also because there is very little wind in winter.

The highest or maximum temperature for a period of twelve years was 82.2° F. at 1.30 P.M., and the lowest or minimum, −7.4° F. at the same time of day. The average relative humidity is 79 per cent. for the year, 82 per cent. for winter, 79 per cent. for spring and 77 per cent. for autumn. The absolute humidity, however, is very slight during the cold months, for it must be remembered that a high relative humidity at a low temperature would be a low one at a high temperature: for instance, the mean relative humidity at Davos for 1876 is given by Weber as 75.2 per cent., and the average yearly temperature is about 38° F. If now the mean temperature were assumed to be 98.4° F., the absolute humidity of the atmosphere remaining unchanged, the relative humidity would have been 11.1 per cent.

At Davos, for the months of January and February, 1890, there were 267 hours of sunshine, and in 1891, 285, or about four and a half to five hours per day.

It will be seen from the above consideration of the various climatic factors of Davos that the characteristic features are a pure, dry, rarefied air, almost complete absence of wind in the winter, and a large amount of sunshine, which in such an atmosphere has great penetrating power. The disadvantages are the snow-melting period in March or April, the shortness of the winter days, and the depressing influences of a monotonous existence in a narrow Alpine valley, covered with snow. When compared with a similar high-altitude climate in Colorado, for example Colorado Springs, the advantages of the latter are apparent: there is more sunshine, and the "invalid's day," is nearly two hours longer in winter. The fall of snow is "infrequent and scanty through the winter," and consequently there is no long period of snow melting in the spring. The vegetation is more abundant and varied, owing to the difference in latitude; and Colorado Springs and most of the other resorts are situated in broad, extended plateaus or open plains, giving one the feeling of freedom and exhilaration which comes from being able to look far away into the distance.

There is, however, one grave disadvantage in many of the Colorado resorts, namely, the wind and dust. For a further comparison of the two regions the reader is referred to a valuable paper by Dr. Carl Ruedi (who resided at both Davos and at Denver), entitled "A Comparison of the Winter Health Resorts in the Alps with some Places in the Rocky Mountains of Colorado," Transactions of the American Climatological Association, vol. x., 1893–94.

The chief disease for which a cure is sought in the Alpine altitudes is pulmonary tuberculosis, and to Davos comes the consumptive, not for relief but for the permanent arrest of his disease; consequently only such cases are suitable for such climatic treatment as offer a reasonable prospect of attaining this end. The following enumeration of suitable cases for the high-altitude treatment is given from the experience of various authorities: (1) Incipient cases; (2) hemorrhagic phthisis, in the early stage of the disease; (3) chronic pleurisy and unresolved pneumonia; (4) patients with more advanced disease showing some consolidation but no excavation nor any serious constitutional disturbance; (5) cases of cavity, if not large and provided the disease is quiescent; (6) cases of imperfect expansion of the thorax.

The contraindications to the high altitude resorts are: (1) Advanced age; (2) the septic state, in which the disease is active and pyrexia constant; (3) double cavities with or without pyrexia; (4) cases in which there is great irritability of the nervous system; (5) diseases of the kidney, liver, or heart; (6) diabetes; (7) great loss of pulmonary tissue; (8) emphysema; (9) tuberculous laryngitis. In regard to the latter disease there is some difference of opinion. Solly, of Colorado Springs, for example, reports favorable results in its treatment in the high altitudes.

Symonds, in his charming book, "Our Life in the Swiss Highlands," thus narrates the "method of cure" at Davos; and although the account was written over twenty-five years ago it still remains essentially true at the present time. He says: "After a minute personal examination of the ordinary kind, your physician tells you to give up medicine, and to sit warmly clothed in the sun as long as it is shining, to eat as much as possible, to drink a fair quantity of Valtelline wine, and not to take any exercise. He comes at first to see you every day, and soon forms a more definite opinion of your capacity and constitution. Then, little by little, he allows you to walk; at first upon the level; next up-hill, until the daily walks begin to occupy from four to five hours. The one thing relied upon is air. To inhale the maximum quantity of the pure mountain air, and to imbibe the maximum quantity of the keen mountain sunlight, is the *sine qua non*."

"When I came to Davos, for example," continues the same author, "at the beginning of August, I could not climb two pairs of stairs without the greatest discomfort. At the end of September I was able to walk one thousand feet up-hill without pain and without fear of hemorrhage. This progress was maintained throughout the winter; and when I left Davos in April the physician could confirm my own sensation that the lung, which had been seriously injured, was comparatively sound again, and that its wound had been healed."

With regard to the results obtained at Davos, Turban, who conducted a sanatorium there, published in 1899 an elaborate report of 408 cases treated by him, one-half of which were in the second stage of the disease, and one-quarter each in the first and third stages. Taking the three stages together, he discharged 66.1 per cent. "absolutely or relatively cured." Of this number 48 per cent. were found—by the examination made by a physician from one to seven years after their discharge from the sanatorium—to have remained absolutely or relatively cured. It must be borne in mind that these results were obtained by the combination of the sanatorium and high-altitude treatment.

Williams ("Aero-Therapeutics," 1894) gives the results in 247 of his own cases, whom he sent to Davos, Arosa, St. Moritz, and other high-altitude resorts. Of this number 161 were in the first stage and 86 in the second and third. A cure was effected in 40.89 per cent.; great improvement in 29.55 per cent., and improvement in 12.95 per cent.

In concluding his remarks upon the effects of the high-altitude treatment, Williams says that 75 per cent. of cases of phthisis generally are greatly improved, and in 43 per cent. the tuberculous process is more or less completely arrested. The beneficial influence of the climate is best shown, he thinks, in cases of tuberculous consolidation, in which improvement may be looked for in 87 per cent. and arrest in 57 per cent.

In a private letter received by the writer from Dr. Peters, of Davos, he says: "After eleven years' practice here in Davos, I can say that in 20 to 25 per cent. of cases a perfect cure, and in about 60 per cent. of all cases a great improvement, is obtained." "As to the treatment," he continues, "the principal thing is to spend as much time as possible outside in the pure, cold, dry, sunny air, lying, sitting, walking, skating, or tobogganing. One must sleep at least seven or eight hours, and make use of the cold shower bath and cold wet rubbings in the morning." Other conditions much benefited by the climate are bronchial asthma, convalescence from acute diseases—pleuritic adhesions, anemia and neurasthenia.

Davos-Platz is the chief center for hotels and pensions and consequently for patients, although Davos-Dörfli in the winter receives the sun's rays two hours earlier, but at the same time loses them earlier.

The accommodations at Davos are abundant and excellent, consisting largely of extensive hotels, all of which are under general medical supervision. There are also several sanatoria, of which Turban's, Spengler's, and Murats' are perhaps the best known. Villas, pensions, boarding-schools for boys and girls, and other accompaniments of a populous and popular resort are to be found here. There are also good accommodations at Davos-Dörfli, which is connected with Davos-Platz by a tramway.

Davos has been accused of being overcrowded and consequently less salubrious, but for this charge there exists no ground whatever, says Williams. The drainage is excellent, and the water supply good. The food is abundant and well served. Davos is reached by rail from Paris, viâ Bâle and Landquart.

The attractions, for those who can safely indulge in them, are skating, tobogganing, sledging, and walking. The daily promenade upon the main street of the village is one of the features of the winter life at Davos. Here one sees the patients with faces bronzed by the sun, protecting themselves from its hot rays by parasols, when the temperature of the air is below zero. Davos is also largely frequented for the winter sports by the English and others. Every care is taken to avoid all danger of infection—no room in hotel or boarding house once occupied by a tuberculous patient is permitted to be again occupied until thoroughly disinfected.

Wiesen, which is about eleven miles below Davos-Platz in the same valley, is also a high-altitude health resort, with essentially the same climatic characteristics as Davos. It has an elevation of 4,757 feet, and instead of lying at the bottom of a valley, is situated about 1,000 feet above the river bed, upon a terrace looking toward the South. Wiesen is said to have rather more sunshine than Davos; a slightly higher and more equable winter temperature, and a winter season which is several weeks or a month shorter than the winter proper at Davos. There is also an early "clearance of snow," and the snow-melting is more

rapid than at Davos. Moreover, there is no morning or evening mist at Wiesen, according to Dr. Wise, in fine weather, whereas at Davos, "a perceptible mist generally covers the valley each morning." There are several good hotels at Wiesen, and it would appear to be fully as favorable as a climatic high-altitude station as Davos. As yet it has not been utilized by any large number of consumptives.

The writer has personally visited the resorts above described, but in the summer when the majority of patients were away. He can, however, testify to the remarkably invigorating quality of the air and the intensity of the sunshine. The sensation produced by the deliciously fine, dry, cool air and the warm sunshine is quite indescribable. One feels as if one could take an unlimited amount of exercise without the least sensation of weariness. The approach to Davos, either by the Landwasser route or viâ Landquart, is one of great scenic attraction. The reader is referred for further information regarding this resort to "Davos as a Health Resort," Davos, 1907, and to Huggend's "Handbook of Climatic Treatment," 1906.

EDWARD O. OTIS.

**Dawson, William W.**—Born in Berkley County, Virginia, in 1824. He received the degree of Doctor of Medicine, in 1850, from the Medical College of Ohio, and afterward spent one year as house physician in the Commercial Hospital, Cincinnati. He then endeavored to establish himself in practice in the country, but, not finding this work very satisfactory, he concluded to try his fortune in Cincinnati. During the years 1854–1893 he occupied in succession the following important positions: Professor of Anatomy, first in the Cincinnati College of Medicine and Surgery (1854–1857), and then in the Medical College of Ohio (1860–1865); Surgeon on the staff of the Cincinnati Hospital (1864–1871) and later (1871–1893) on that of the Good Samaritan Hospital; Professor of Surgery in the Medical College of Ohio (1871–1884); and, finally, Professor of Clinical Surgery in the same institution (1884–1893). His death occurred February 16, 1893.

Dr. Dawson contributed many articles—all of them on surgical topics—to current medical literature. Stone, in his "Biography of Eminent American Physicians and Surgeons," says: "Dr. Dawson was rapid, at times brilliant, as an operator, and his operations covered almost every department of operative surgery. But his hand was controlled by that degree of safe conservatism which comes only of knowledge—a knowledge of the science as well as the art of surgery. . . . . He was a man who, under all circumstances, spoke the truth, hated hypocrisy, deceit, and shams. Conspicuous for such traits of character, he could only be beloved and honored by the laity and by the Profession."

A. H. B.

**Dead, Disposal of the.**—The "Judgment of the Dead" obtained among the ancient Egyptians; even kings were submitted to it. Judges selected among the oldest and most respectable citizens examined minutely the past life and conduct of the deceased; if this was satisfactory the body could be transported to the Necropolis, otherwise it was thrown into the common fossa or trench. The old Hebrews embalmed before burial the bodies of the well-to-do and the illustrious; the common people were buried unembalmed; the practice to-day is in effect the same. It would seem from some scriptural passages that certain of the Jews were cremated.

The old Persians, in common with most Oriental peoples, considered a cadaver impure; and they would not contaminate the elements, which they adored, either by cremation or by burial or by casting into the waters. Each Persian town possessed beyond its walls two high stone towers—one of white, the other of black stone. As among the Egyptians, the dead were judged—but by the priests, who ordered the bodies of the good to the white tower, of the iniquitous to the black one. Buzzards were kept for the purpose of devouring the dead and thereby preventing infection; but infection must nevertheless have ensued, because these birds would foul the neighborhood of those towers and the water courses nearby by dropping infected and decomposing masses of the flesh of the dead.

Among the Parsees (sun worshippers) death was not considered a misfortune; and lamentations were forbidden by law. The funeral ceremonies ended generally in a great banquet; the "funeral baked meats," of which Hamlet spoke, were evidently not a new thing under the sun.

In ancient Greece funeral ceremonies were attended with great pomp, and were religiously practised, for it was believed that otherwise the souls of the dead could not enter Elysium. Immediately a person died a piece of money, with which to pay the passage to eternity, was put in the mouth. The body was washed and anointed with perfumed oil; it was then robed in the finest white garments, while the head was crowned with flowers. The corpse was then exposed at the main door of the house; precious vases, to be buried with it, were placed by the side of the bier; and nearby were put a cake made of honey and a vessel of water, in which the friends and assistants could purify their hands. Relatives surrounded the death bed, all in deep sorrow. The body was either buried or cremated, for both methods existed among the Greeks—cremation being probably given the perference. In the Iliad not only the dead, but animals, slaves, and captives were also burned, as when Patroclus was cremated. The buried were placed in coffins of various shapes, mostly earthernware. Interments took place outside city walls, as burials in the center of the town were considered a danger to the living. Herein the Greeks were very much wiser than many a modern community. Mortuary banquets were the prevailing custom, and superb monuments were often erected over the site of burial. Today such architecture is reduplicated in most of our cemeteries. As among the Egyptians, criminals and paupers were thrown into special excavations; our potter's fields are a modern refinement of this custom.

The Romans followed the Greeks in the disposal of their dead. Couches or litters, on which the body was carried by the nearest relatives (as by our pall-bearers to-day), were made of ivory covered with gold and purple—the funerary color among the Romans. The funeral processions of the great were halted at the rostrum of the Forum, for orations to be made, as when Mark Antony eulogized Caesar. There was either cremation or sepulture—and always outside the town walls. As in Greece the *pyra*, the funeral pile, on which the corpse was placed, was perfumed and at times richly ornamented. Prisoners and slaves might be sacrificed on the *pyra;* while banquets and gladiators' combats were held when the great died.

The first Christian cemeteries, consecrated in the beginning of the third century, were also located outside towns; later on, whether from sentiments of piety or of vanity, many of the faithful, especially bishops and other high functionaries, sought the honor of being buried in the interior of churches. Nor is this latter mode of doing honor by any means obsolete to-day, despite the objections of sanitarians.

Few cemeteries that were built during the Middle Ages remain—a fact later to be reverted to with relation to cremation. In order to diminish as much as possible the dangers of earth and vault burials, all civilized communities have made stringent police regulations governing cemeteries. These should invariably be located outside towns and thickly settled regions. Yet here the object of such wise ordi-

nances has been frustrated: as when towns (such as New York) have developed rapidly into great cities, so that the habitations of the living come in time to encroach upon and environ those of the dead. Cemeteries should be planted with trees, with due regard to ventilation; each grave should have a depth of from four to six feet, and there should be at least three feet distance between them.

Decomposition of a body is more or less rapid according to climate, conditions of soil, the material of the coffin, the clothing or coverings of the body, and so forth. In the East, to-day as in Scriptural times, burial must come soon after death, else "the body stinketh." Low, damp, moisture-saturated ground, hastens decay. Embalming, a metal coffin, or a cement enclosure of the coffin retards decay. Rapid decomposition should be favored by all possible means. Burial in the earth is preferable to above-ground, intermural, or brick-vault burial; the former facilitates decomposition of the tissues and absorption by the earth of obnoxious gases and emanations. And yet, with all such precautions ground burial, especially in populous towns and districts, remains a dangerous and unsanitary practice. The earth soon becomes saturated with products of decomposition—which permeate the soil and water and may be carried to great distances.

*Burial at sea* has been advocated. There can hardly be a more impressive ceremony. Whenever this mode of disposing of the dead obtains the body is weighted with shot or otherwise, in order that it may not later arise to the surface.

*Embalming* a dead body is done in order to preserve it from decomposition and to keep it intact for so long as is possible. It is, of course, a most invaluable practice when people have died abroad, and their own are anxious to see them once again, before consigning them to the elemental dust from which they have sprung. Nearly all nations of antiquity embalmed their dead. The Egyptians, it would seem, were supreme masters of that art; their mummies, now fairly intact, date back many centuries, to practically the beginning of recorded history. Their method of *mummification* was: first, removing all the viscera from their cavities and dissolving them in caustic liquid; second, submitting the body for seventy days to the action of carbonate of sodium (to remove all fatty substances); third, obtaining desiccation by exposing the body to the air or to the heat of an oven. While undergoing this desiccation, the body was varnished externally and filled internally with odoriferous substances destined to keep away insects; or it was plunged in melted bitumen or wax, which permeated every part. Finally, innumerable bandages dipped in gums were applied most carefully over all parts of the body, thus excluding air and humidity. Mummification was of course greatly aided by the dryness and the permanent high temperatures which have ever obtained in Egypt.

During the Middle Ages and even later, the illustrious were embalmed by methods which more or less imitated those of ancient Egypt. In our day, thanks to modern chemistry, numerous substances are at hand capable of preventing decomposition—bichloride of mercury, acetic acid, sulphuric acid, sulphate of iron, chloride of zinc, arsenic, and so forth. Bichloride of mercury and arsenous acid are perhaps the most efficient, but may be objectionable from the viewpoint of medical jurisprudence. In "coroner's cases" indeed, embalming is prohibited by law, until that official has taken the action prescribed. Undertakers find chloride of zinc or formaldehyde effective—injected in the popliteal artery in both directions. Dr. Felix Formento stated in a former edition of this HANDBOOK that Professor Garini of Italy had discovered a process of embalming, which he had kept secret, by which anatomical preparations and whole bodies were made to present the hardness of stone and the appearance of wax and could be preserved indefinitely; the result was a sort of petrification.

Under certain natural conditions dead bodies are known to have kept intact and mummified, and without putrefaction, indefinitely. Congelation prevents decomposition. The flesh and skin of mammoths buried in Siberian ice, have been found unaltered. Humboldt found natural mummies in Mexico. Travelers in Peru found mummified dead bodies of Spaniards and Peruvians that had been lying for centuries on a dry soil and in a burning atmosphere. Bodies seem to become mummified in certain soils, as in that of the cemetery of St. Nicholas, in Toulouse, France. Under favorable conditions a constant current of cold, pure air, in a high altitude will produce the same results. Under the tower of a church near Bordeaux is a cave containing one hundred naturally mummified bodies; and at San Micheli in Piedmont there is a cave containing mummies of monks in their robes and looking perfectly natural. Some of these latter mummies date back several centuries.

*Premature Burial.*—"To be buried alive is, beyond question, the most terrific fate which has ever fallen to the lot of mere mortality. That it has frequently, very frequently so fallen, will scarcely be denied by those who think. The boundaries which divide life from death are at best shadowy and vague. Who shall say when the one ends and when the other begins? We know that there are diseases in which occur total cessations of all the apparent functions of vitality, and yet in which these cessations are merely suspensions, properly so called. They are only temporary pauses in the incomprehensible mechanism. A certain period elapses, and some unseen mysterious principle again sets in motion the wheels of life." The probability is that many stories of premature burial would hardly come up to scientific requirements as to evidence. Where bodies have been found distorted in the tomb it is probable that, in most cases, the gases evolved in putrefaction have been responsible for the position altered from that in which the dead were laid before their obsequies. And yet it is possible that living people have been prematurely buried. To prevent this laws have been suggested forbidding burial until evidences of decomposition are present or until death is indubitably established by certain tests. (See *Death, Signs of.*) Of course the process of embalming renders premature burial impossible. In Germany, Hufeland, in Weimar, achieved the operation of laws regulating the disposal of the dead, which were soon afterward adopted also at Frankfort, Dresden, Munich, and Berlin, and to which all the leading German cities are now subject. The German system, however, is content with preventing premature burial solely by means of the mortuary; and does not seem to provide any tests to determine absolutely if the person has died.

*Cremation.*—Many books and papers have during several decades past been published throughout Europe and the United States advocating cremation or incineration in preference to burial—the former being recommended as a safe, rational, and unobjectionable practice, tending to destroy powerful causes of disease and greatly to promote the public health. Under the empire, thousands of French soldiers, who had perished during the disastrous retreat from Moscow, were burned by the Russians. In 1814 after the battles around Paris, more than four thousand dead bodies were incinerated within a fortnight in order that infection might not spread. The like was done after Sedan in 1870. Since 1876 cremation has been introduced in almost every civilized country. In Italy this great sanitary reform has been carried forward with energy and success.

In America cremation was advocated by Henry Laurens (a military attaché and friend of General

Washingtion), the first person whose remains were formally cremated on this side the Atlantic, by Henry Barry of South Carolina, whose remains were burned, according to his instructions, in his own garden; by the Rev. Dr. Bengless, of Brooklyn, who wrote much of the advantages of cremation; and by Dr. J. T. Le Moyne, of Washington, Pa., who besides writing and speaking in behalf of cremation, had a crematorium erected in which his remains were burned, and which still stands a monument to his zeal and earnestness in this cause. One of America's greatest surgeons and scientists, Dr. Samuel D. Gross, of Philadelphia, was incinerated in Dr. Le Moyne's crematorium. Numerous medical societies have given this practice their sanction and approval.

It may indeed, fairly be said that at all times, and in every country, earth burial has been strongly condemned by the most enlightened men. In 1874 Sir Henry Thompson observed: "No dead body is ever placed in the soil without polluting the earth, the air, and the water above and around it." Gravediggers are "mostly pale of face and seldom healthy;" few of them live to old age. Koch, Ewart and Carpenter demonstrated that the blood of animals dying of splenic fever may be dried and kept virulent for years, and pulverized into dust, the bacteria in it surviving to produce infection.

The contamination of wells, fountains, and running water in and around burial-grounds may extend a considerable distance. Such waters present a sparkling and seductive appearance due to a large proportion of nitrates and nitrites. "The surest carrier and the most deadly, fruitful aider of zymotic contagion is this brilliant enticing-looking water charged with the products of decomposition." (*Lancet.*) In passing it should be observed that when in a case of virulent infection the family nevertheless determines on burial, the coffin should be encased in cement.

In the light of recent indubitable knowledge regarding the transmission of bacteria to the well by insects, one must fear that cases of infection have been due to the conveying, by flies, of germs from the soil of burying grounds. Felix Fomento relates the incident of a sheep which died of anthrax and was buried twenty feet in the ground in a field which, for a decade or more after, ceased to be used as a pasture ground. Some healthy sheep were then pastured in that field; soon after, three sheep were taken sick and died of anthrax, at a time when this disease did not exist in the locality or the environs. It was found that the sheep ten years before affected with anthrax was the cause of the new outbreak; and Pasteur demonstrated the bacillus to have been brought to the surface by earthworms. One may thus easily believe that cemeteries may be the habitat of virulent microorganisms.

From the moment of physical death putrefaction begins, until, after a variable time, perhaps many years, all the elements that constituted the body are finally liberated by a process of slow combustion. During this process every particle of matter about that body is being saturated and infected. Cremation—a process of rapid combustion—affords the only right solution of the problem of the disposal of the dead; by this means alone can infection from the dead be obviated. The ashes from the cremated remains of those who have died of smallpox, plague, or yellow fever are as clean and as innocuous as those of the most precious woods or metals. Cremation should certainly be preferred to the potter's field. The relics of the dissecting room or of the dead house should be properly incinerated. In epidemics the crematory flame should be made, by law, the great purifier. Nor will it help to establish the cemetery at great distances from the city; besides the reason we have given, this is but planting the seeds of disease in another place.

An important consideration is that of economy of space. London's annual burials are calculated to fill twenty-two and one-third acres of ground; on the other hand Greenwood Cemetery alone could receive twenty million urns. Again, cremation would obviate the desecration of tombs and the theft of dead bodies, and it offers the advantage and the consolation to the survivors of being able to preserve and transport the ashes of the beloved. An English clergyman observed: "I have lost three dear kinfolk in remote quarters of the earth, and I would give everything I could command if I could receive their ashes and keep them by me in a vase." The process has been described as follows: "The body is borne into the chapel and placed on a catafalque, which stands in front of the altar. The section of the chapel floor upon which the body rests constitutes the floor of a lift or elevator. As the funeral service proceeds, the elevator invisibly and noiselessly descends, bearing the body to the basement in front of the incinerator, which by means of superheated air has been raised to a white heat within, at a temperature of about 1,500° F. As the door of the incinerator is opened to receive the body, the inrushing cold air causes the temperature to fall a little, and gives to the interior a beautiful rose hue. The corpse, wrapped up in a sheet saturated with alum or asbestos, and placed on a metallic bed, passes over rollers into a bath of rosy light. The sheet delineates the form of the human body until incineration is complete, and the bones crumble into ashes under the mystic touch, as it were, of an invisible agent. This process may be called the etherealization or spiritualization of the human body. It requires about an hour per 100 pounds of the original weight. A few pounds of clean, white ashes are dropped by means of a lever into the ash chamber below, and are drawn thence into an urn of terra-cotta, marble, alabaster, or other suitable material, and returned by means of the elevator to the catafalque. The service or ceremony being now over, the friends of the deceased find the ashes just where they had last seen the body of the departed. . . . . The process is accompanied with no perceptible sound, smell, or smoke, and presents absolutely nothing that can offend the susceptibilities of the most fastidious." Connected with the crematorium are rooms for autopsy and medicolegal researches, when deemed necessary.

Movable crematoria, on wheels, intended for war have been invented.

JOHN B. HUBER.

**Deaf-mutes.**—DEFINITION AND CLASSIFICATION. The word "deaf-mutes" signifies, strictly speaking, persons who, having been born deaf or having lost their hearing in early life, have not acquired the power of speech. There is usually no defect in the vocal organs, except such imperfection of development as may be the result of lack of exercise; muteness is simply the consequence of deafness. Ordinary children learn to speak by hearing and imitating the sounds made by others; the deaf child does not hear such sounds, therefore does not imitate them, therefore remains mute.

The term "deaf-mutes" seems to have originated in the United States within the present century. The synonymous term generally employed in England and still frequently used in this country is "deaf and dumb." Of these two designations, "deaf-mute" is the preferable one; for (1) the words "deaf and dumb" tend to perpetuate the popular error that deafness and dumbness are two distinct physical defects, instead of standing, as above explained, in the relation to each other of cause and effect; and (2) the word "dumb" is open to the further objection that it carries with it an implication of stupidity and brutishness, being associated in the minds of many people with disparaging allusions to the lower animals, as in

the Scriptural expression "dumb dogs," and in Longfellow's reference to "dumb, driven cattle."

There are many persons usually spoken of as "deaf-mutes," or "deaf and dumb," and educated in institutions established for the instruction of this class, who are not properly described by either of these terms. Some of them, having lost their hearing by accident or disease, after they had learned articulate language, still retain their speech notwithstanding their deafness; others, formerly deaf-mute and still deaf, have acquired the art of speech through the instruction of skilful teachers of articulation. Such persons are not really "dumb" or "mute," and their improper classification as such—especially in the case of those who have learned to speak before losing their hearing—gives rise to serious errors in the mind of the public concerning the nature of deaf-mute education and its results. The strictly correct designation for the whole class of persons under consideration in this article is "the deaf"; the term "deaf-mute" should be applied only to persons deaf from birth or infancy who have not acquired the use of articulate speech.

Some deaf-mutes are either born deaf, or, losing their hearing in early infancy from unobserved causes, are supposed to have been so born; others become deaf from various diseases or from accidents. The deaf are thus divided into two great classes: the "congenitally" and the "adventitiously" deaf, or, as they are often called, "congenital deaf-mutes" and "adventitious deaf-mutes." Except when hearing is known to have existed, it is impossible to say positively to which of these classes a deaf-mute belongs (see Proportion of Congenital and Adventitious Cases, *infra*); the distinction nevertheless is an important one, especially from an educational point of view.

Congenital deaf-mutism is sometimes hereditary and sometimes sporadic. In any inquiry into the causes of deafness this distinction is no less important than that between congenital and adventitious deafness. From an etiological point of view, then, there are three great classes of deafness: hereditary deafness, sporadic congenital deafness, and adventitious deafness.

Among the adventitiously deaf, a large proportion lose their hearing in early childhood, before they have learned articulate language; in other cases in which some progress in speaking has been made, the length and severity of the disease that causes deafness, often temporarily affecting the brain at the same time, seem to efface the language previously acquired; and in others the neglect of parents and friends to aid and encourage the deaf child in the extraordinary efforts necessary for the retention of speech after hearing is lost produces the same result. Such persons are sometimes called "quasi-congenital deaf-mutes." Speech as well as hearing is gone, and they as truly belong to the class of "deaf-mutes" as if they had never heard.

Many persons have lost their hearing by accident or disease, after having acquired the use of articulate speech, and retain this speech more or less perfectly notwithstanding their deafness. If the loss of hearing occurs in adult life, they usually escape the improper classification with deaf-mutes above referred to; but if it happens in childhood, so that they cannot be educated in the usual manner of hearing children, but must be sent to special schools for instruction, they are erroneously included among deaf-mutes. Many of the processes of deaf-mute instruction are, it is true, equally applicable to persons of this class, and they may therefore properly be associated with deaf-mutes for the purpose of education; but they differ from deaf-mutes essentially, not only in having the ability to express themselves orally, but still more in their natural mode of thought, which is in words and not in gestures. This difference is fully recognized by all teachers of the deaf, who in this country distinguish the members of this class by the useful and convenient, though not accurately descriptive, title of "semi-mutes."

The deaf may be further classified according to the degree of their deafness. Deafness varies all the way from a slight difficulty in hearing to the inability to perceive the loudest sounds. Persons in whom the defect is so slight as to allow of their education through the ear in ordinary schools are not regarded as deaf-mutes, and do not come within the scope of the present article; they may be designated as simply "hard of hearing." The whole class of the deaf, aside from the hard of hearing, are divided into "the totally deaf" and "the semi-deaf." The hereditarily deaf are seldom totally deaf, but the amount of their hearing is generally so slight as to be of no practical value. Deafness caused by diseases affecting the inner ear, as meningitis, is usually total; by those affecting the middle ear, as scarlet fever and measles, sometimes total and sometimes slight.

The term "mute" is often used as synonymous with deaf-mute, but it should be avoided as less exact, since it may also refer to persons who hear, but are not able to speak on account of feeble mental power or of some defect in the vocal organs. It is open to the further objection that it suggests to many minds an undertaker's assistant at a funeral. Persons "mute" or "semi-mute," but not deaf, are, of course, not to be included among deaf-mutes, and are not, as a rule, suitable candidates for admission to schools for the deaf. If, as is usually the case, their muteness is due to defective mental power, they may properly be sent to a school for the feeble-minded, where they will receive suitable treatment. In the rare cases where the muteness is due to some imperfection in the vocal organs, the power of speech may sometimes be obtained through a surgical operation or may be imparted by competent articulation teachers in schools for the deaf. In the latter case, after speech is once acquired, the further education of the child can be carried on to best advantage in a school for hearing children.

Extent of Deaf-mutism.—For a large part of the world we have, of course, no statistics of deaf-mutism; but during several decades most of the countries of Europe and North America have included such statistics in their census returns. The returns from different countries, and from different parts of the same country, show remarkable differences in the extent of deaf-mutism. These differences are doubtless due in part to the greater accuracy with which the census is taken in some places than in others; but it is probable that place of residence, race, and modes of living have considerable influence. Mountainous regions give a larger proportion of deaf-mutes than low, level countries; the Caucasian than the African race; Jews than Christians; the poor and ignorant than the intelligent and well-to-do classes. Switzerland has the largest proportion of any country of which we have returns, 2,402 deaf-mutes in every million inhabitants; the Netherlands has the lowest, 340 in every million. In the United States, according to the census of 1910, there are 44,896 "deaf and dumb," a proportion of 488 in every million inhabitants or one in every 2,048.

*Proportion of Males and Females.*—In the general population there are more males than females, the proportion according to the census of 1900 being 51.1 per cent. male to 48.9 per cent. female. Among the deaf likewise the males are more numerous than the females and the disparity is considerably greater than in the general population. According to the same census the proportion among the deaf was fifty-four per cent. male to forty-six per cent. female. This excess of deafness among males is sometimes explained on the hypothesis that males are more exposed to accidents than females, and are more

susceptible to certain diseases that produce deafness. There is probably some truth in this hypothesis, but it does not wholly explain the phenomenon; for males predominate among the congenitally deaf as well as among those who become deaf from accident and disease. Of the congenitally deaf reported in the census of 1900, 52.6 per cent. were male and 47.4 per cent. female. The explanation of the large excess of males over females among the deaf, which has appeared in all the censuses of the United States and in those of foreign countries, remains a problem for the future.

*Proportion of Congenital and Adventitious Cases.*—In the census of 1900 the age when deafness is supposed to have occurred was more fully reported than in any previous census. It was definitely stated in 35,479 cases. Of these 35.5 per cent. were reported as congenitally deaf; 52.4 per cent. as becoming deaf after birth and under two years of age; 73.7 per cent. under five; 90.6 per cent. under twenty. The proportion reported as congenitally deaf was much smaller than in any previous census; but as the returns under the competent direction of Dr. Alexander Graham Bell, were more carefully studied and more fully verified than in any previous census, they were probably more accurate. (Here, as elsewhere in this article when the census of 1900 is quoted, the 51,861 persons able to understand loud conversation, who were erroneously returned by the enumerators and who swell the total number of the deaf reported by that census to 89,287, are not included.)

It should be remembered, however, that all statistics concerning congenital and adventitious deafness are somewhat questionable, for the fact of congenital deafness cannot be determined with absolute certainty in any case. At the moment of birth it is impossible to find out whether the power of hearing exists or not, though a few days later, probably, this can be ascertained by applying proper tests. Generally, the fact of deafness is not discovered until the child arrives at the age when children usually begin to talk; at that time it is impossible to say whether the deafness has existed from birth or has occurred at some subsequent period. If the child has suffered from some unmistakable disease that is known to be a frequent cause of deafness, as meningitis, or if it has had a fall, the case is likely to be recorded as adventitious; it may possibly, however, have been congenital. If, on the other hand, no such disease or accident has been observed, the case is likely to be recorded as congenital; but it is possible that the hearing has been lost in early infancy from some unobserved cause. It is to be understood, therefore, that "congenitally deaf," as a rule, really means "supposed to be congenitally deaf," and that "adventitiously deaf," in cases reported as becoming deaf under two years of age, means "supposed to be adventitiously deaf."

*Proportion of Hereditary Cases.*—We have no exact statistics showing the number of cases in which deafness is hereditary. Dr. J. K. Love, of Glasgow, who has given much attention to this subject, estimates that about fifteen per cent. of all the deaf are cases of true hereditary deafness. This does not mean that fifteen per cent. of the deaf are the children of deaf parents. In a great majority of the instances of hereditary deafness the parents are hearing persons, and the defect has been handed down from a deaf grandparent or some more remote progenitor through hearing parents or, it may be, through several generations of hearing ancestors. (See Heredity, *infra.*)

Causes of Deaf-mutism.—The immediate cause of mutism, in the great majority of persons who do not speak, is simply deafness. (See Definition and Classification, *supra.*) Where this is not the case, as occasionally occurs in children improperly brought to schools for the deaf, there is usually some mental defect which has prevented the development of speech. Such mutism "is the result of the absence either of ideas or of reflex action in the motor organs of speech. In the former case, imbeciles have nothing to say; in the latter, they feel no desire to speak." Very rarely, indeed, it happens that mutism is due to some defect or paralysis of the vocal organs that interferes with articulation. But as neither of these groups of "hearing mutes" belongs to the class of deaf-mutes, they do not come within the scope of the present topic. Since deafness is the immediate cause of mutism in all deaf-mutes, in order to ascertain the causes of deaf-mutism we must inquire into the causes of deafness.

The causes of deafness may be divided into direct and indirect causes. The direct causes are the defects in the middle or internal ear which prevent the perception of sound. The indirect causes are the circumstances of environment, disease, or accident, either antenatal or postnatal, or both, accompanying or preceding deafness in so large a number of cases as to give us reason to suppose that they have an important influence in producing those defects.

In discussing this subject it was formerly usual, setting out with the classification of deaf-mutes into congenital and adventitious cases, to ascribe all the former to antenatal, and all the latter to postnatal, causes. This distinction cannot be maintained. There are probably both congenital and adventitious cases, and there are, doubtless, both antenatal and postnatal causes; but (see Proportion of Congenital and Adventitious Cases, *supra*) it is impossible in any case of supposed congenital deaf-mutism to say certainly that it is not adventitious, while, as will appear below, there is reason to believe that antenatal causes, either alone or in combination with postnatal causes, sometimes produce adventitious deafness. Every case should be considered by itself; just as careful inquiry should be made, on the one hand, concerning all possible antenatal causes in cases known to be adventitious as in those supposed to be congenital, and, on the other, concerning all possible postnatal causes in cases supposed to be congenital as in those known to be adventitious. This has not usually been done; when it is, we may expect to arrive at a much clearer understanding of the causes of deafness than has yet been reached.

*Heredity.*—Hereditary deafness and congenital deafness are not synonymous terms. "Some types of deafness," says Dr. Love, "do not come on till adult life, and yet they are hereditary, *e.g.* otosclerosis; others begin *in utero* and yet are not necessarily hereditary, *e.g.* syphilitic deafness. The beginning of a child's life is not when it is born but when it is conceived. A poison may enter the system of the mother and destroy or prevent the development of the organ of hearing. The deafness resulting is congenital but it is not necessarily hereditary. True hereditary deafness is due to a cause which operates from the period of conception, and this cause is present in the germ plasm of one or both of the parents."

Heredity is the first and one of the most effective causes of deaf-mutism. This is sometimes questioned, for the reason that deaf-mute parents do not, as a rule, have deaf-mute children; but, aside from the fact that the exceptions to this rule are of themselves numerous enough to establish the principle of heredity, its existence is clearly proved by the large number of deaf-mutes who are related to one another by blood. Of 34,780 deaf persons reported in the census of 1900, 8,171, or 23.5 per cent., had deaf brothers, sisters, ancestors, uncles, aunts, cousins, or other relatives, not including husbands, wives, or children. Many of these cases had more than one deaf relative, making the groups of related deaf-mutes much fewer than the total number of related deaf-mutes reported; but they none the less forcibly illustrate the tendency of deafness to prevail in certain families—a tendency which can be explained only by the principle of

heredity. Deafness affecting brothers and sisters is generally regarded as the most conclusive evidence of its heredity, but statistics prove that this is not a more important indication than the existence of deafness in other relatives, as cousins, uncles, and aunts. Dr. Love indeed regards it as a less trustworthy indication, inasmuch as the deafness of several brothers and sisters in a family may be due to some epidemic of childhood, as scarlet fever, and even when the deafness of brothers and sisters is congenital it may be of a syphilitic type and therefore not hereditary.

Hereditary deafness seems to play a much more important part in producing deafness among the congenitally deaf and those who become deaf from catarrhal affections than among those who lose their hearing from other causes. Of 11,693 persons reported as congenitally deaf in the census of 1900, 4,693, or 40.1 per cent. had deaf brothers, sisters, or ancestors; and of 2,693 deaf from catarrhal affections, 698, or 25.9 per cent., had such relatives; while of the 14,492 who became deaf from scarlet fever, measles, meningitis, etc., only 1,621, or 11.2 per cent., had such relatives. The large proportion of cases supposed to be congenital among those having deaf relatives indicates that the hereditary tendency to deafness, where it exists, is generally so strong as to produce the result—whether independently or in conjunction with some other indirect cause that is not observed—either before or soon after birth; while the considerable number of known adventitious cases having deaf relatives shows that the inherited tendency not infrequently awaits the concurrence of some disease, perhaps not hereditary in its character before manifesting itself. It should be remembered that though we speak of hereditary deafness, what is inherited in any case of deafness, whether congenital or adventitious, is not really deafness, but some defect of the auditory organs or of the nervous system, of which deafness is but the result or the symptom.

While the principle of heredity is thus clearly established as an indirect cause of deafness, it is the fact that in a great majority of cases the defect is not transmitted by deaf parents to their children. Still, marriages of the deaf are more likely to result in deaf offspring than ordinary marriages. Of 3,078 marriages of deaf persons in America, one or both of the partners being deaf, the results of which are known, 300, or nearly 10 per cent., resulted in deaf offspring; of the 6,782 children born of these marriages, 588, or 8.5 per cent., were deaf. The percentage of ordinary marriages resulting in deaf offspring is not known; it is certainly less than one per cent.

For the hereditary transmission of the physical condition that results in deafness, it is not necessary that both of the partners in marriage should be deaf. On the contrary, taking the deaf as a whole, without regard to the character of the deafness, marriages in which both of the partners were deaf have not resulted in a larger proportion of deaf offspring than those in which one of the partners was deaf and the other a hearing person. Of 2,377 marriages in which both partners were deaf, 220, or 9.25 per cent., resulted in deaf offspring; of 599 marriages in which one partner was deaf and the other hearing, 75, or 12.5 per cent., resulted in deaf offspring. Of 5,072 children born of the marriages in which both partners were deaf, 429, or 8.5 per cent., were deaf; of 1,532 children born of the marriages in which one partner was deaf and the other hearing, 151, or nearly 10 per cent., were deaf. These results are contrary to expectation and are doubtless due to the circumstances (1) that in many of the marriages where both partners were deaf neither of them was hereditarily deaf; (2) in many of them the deafness of husband and wife was of a different character and there was consequently not a union of "like with like"; (3) in many of the marriages where one partner was deaf and the other could hear, the latter as well as the former belonged to families in which deafness was hereditary and both partners, therefore, transmitted the "determiner" of deafness to their offspring. Where the deafness of both partners is of the same character, as it probably is in many marriages of the congenitally deaf and in most consanguineous marriages of deaf persons, there is a great intensification of the liability to deaf offspring. Of 335 marriages in which both partners were reported as congenitally deaf, 83, or 25 per cent., resulted in deaf offspring; and of the 779 children born from those marriages, 202, or 26 per cent., were deaf. Of 31 consanguineous marriages of deaf persons, one or both of the partners being deaf, 14, or 45 per cent., resulted in deaf offspring, and of 100 children born therefrom, 30 were deaf.

Congenitally deaf persons, whether they are married to one another, to adventitiously deaf, or to hearing partners, are far more liable to have deaf offspring than are adventitiously deaf persons. Of 1,681 marriages in which one or both partners were congenitally deaf, 151, or 9.5 per cent., resulted in deaf offspring; of the 3,740 children born from these marriages, 321, or 8.5 per cent., were deaf. The liability is nearly trebled, as is shown in the preceding paragraph, when both of the partners are congenitally deaf.

Marriages of adventitiously deaf persons are more liable to result in deaf offspring than ordinary marriages, but when both of the partners are adventitiously deaf or one of them is a hearing person the liability is slight. Of 845 marriages in which both partners were adventitiously deaf, 30, or 3.5 per cent., resulted in deaf offspring; of the 1,720 children born from these marriages, 40, or 2 per cent., were deaf. Of 310 marriages in which one partner was adventitiously deaf and the other hearing, resulting in 713 children, the percentages of marriages resulting in deaf offspring (3.2 per cent.) and of deaf children born therefrom (2.2 per cent.) were nearly the same as in the marriages in which both partners were adventitiously deaf.

Deaf persons having deaf relatives, and hearing persons having deaf relatives and married to deaf partners, are very liable to have deaf offspring. (Probably hearing persons having deaf relatives and married to hearing partners, especially if the latter also have deaf relatives, are subject to the same liability; but while many instances of marriages of this kind resulting in deaf offspring have been observed, no thorough and systematic investigation of them has yet been made.) However the marriages of the deaf are classified with respect to the deafness or hearing of one or both of the partners, or with respect to the congenital or adventitious character of the deafness, the percentage of marriages resulting in deaf offspring and of deaf children born therefrom is almost invariably highest where both of the partners have deaf relatives, next highest where one of them has deaf relatives and the other has not, and least where neither has deaf relatives. Where neither of the partners has deaf relatives, especially if neither of them is congenitally deaf, the liability to deaf offspring is very slight, perhaps not greater than in ordinary marriages. While congenital deafness, then, may be a *prima facie* indication of a liability to deaf offspring, it is not to be accepted as a conclusive evidence of such liability, for, as has been shown, congenital deafness is not always hereditary; but the possession of deaf relatives is a trustworthy indication of hereditary deafness and therefore of a liability to deaf offspring. If a deaf person, whether congenitally or adventitiously deaf, has deaf relatives, that person, however married, is liable to have deaf offspring, the liability being much greater, however, in the case of the congenitally deaf than of the adventitiously deaf; and if a deaf person, either with or without deaf relatives, marries a person, whether deaf or hearing, who has deaf relatives, the marriage is

liable to result in deaf offspring. If both partners have deaf relatives, the probability of deaf offspring is largely increased.

The most dangerous form of marriage for a deaf person seems to be a union with a near relative, whether that relative is deaf or hearing. Such marriages, as has been shown above, are more liable to result in deaf offspring than any other. The reason is, probably, that the same "determiner" tending to produce deafness, derived from a common ancestor, is likely to exist in the germ plasm of both partners.

The following table gives a summary of the 3,078 marriages having one or both of the partners deaf, from which the conclusions above stated are derived. The table shows the number of marriages of each class, the number and percentage of each class resulting in deaf offspring, the number of children born from the marriages of each class, and the number and percentage of them that were deaf. The fifth and sixth columns of this table, giving the percentage of marriages resulting in deaf offspring and the percentage of deaf children born therefrom, indicate at a glance the comparative liability to deaf offspring of the several classes of marriage. The extremes of liability are found in the two classes last named in the table.

| Marriages of the deaf. | Number of marriages. | | Number of children. | | Percentage. | |
|---|---|---|---|---|---|---|
| | Total. | Resulting in deaf offspring. | Total. | Deaf. | Marriages resulting in deaf offspring. | Deaf children. |
| One or both partners deaf | 3,078 | 300 | 6,782 | 588 | 9.7 | 8.6 |
| Both partners deaf | 2,377 | 220 | 5,072 | 429 | 9.2 | 8.4 |
| One partner deaf, the other hearing | 599 | 75 | 1,532 | 151 | 12.5 | 9.8 |
| One or both partners congenitally deaf | 1,477 | 194 | 3,401 | 413 | 13.1 | 12.1 |
| One or both partners adventitiously deaf | 2,212 | 124 | 4,701 | 199 | 5.6 | 4.2 |
| Both partners congenitally deaf | 335 | 83 | 779 | 202 | 24.7 | 25.9 |
| One partner congenitally deaf, the other adventitiously deaf | 814 | 66 | 1,820 | 119 | 8.1 | 6.5 |
| Both partners adventitiously deaf | 845 | 30 | 1,720 | 40 | 3.5 | 2.3 |
| One partner congenitally deaf, the other hearing | 191 | 28 | 528 | 63 | 14.6 | 11.9 |
| One partner adventitiously deaf, the other hearing | 310 | 10 | 713 | 16 | 3.2 | 2.2 |
| Both partners had deaf relatives | 437 | 103 | 1,060 | 222 | 23.5 | 20.9 |
| One partner had deaf relatives, the other had not | 541 | 36 | 1,210 | 78 | 6.6 | 6.4 |
| Neither partner had deaf relatives | 471 | 11 | 1,044 | 13 | 2.3 | 1.2 |
| Both partners congenitally deaf; both had deaf relatives | 172 | 49 | 429 | 130 | 28.4 | 30.3 |
| Both partners congenitally deaf; one had deaf relatives, the other had not | 49 | 8 | 105 | 21 | 16.3 | 20.0 |
| Both partners congenitally deaf; neither had deaf relatives | 14 | 1 | 24 | 1 | 7.1 | 4.1 |
| Both partners adventitiously deaf; both had deaf relatives | 57 | 10 | 114 | 11 | 17.5 | 9.6 |
| Both partners adventitiously deaf; one had deaf relatives, the other had not | 167 | 7 | 357 | 10 | 4.1 | 2.8 |
| Both partners adventitiously deaf; neither had deaf relatives | 284 | 2 | 550 | 2 | .7 | .3 |
| Partners consanguineous | 31 | 14 | 100 | 30 | 45.1 | 30.0 |

The results above stated are in accordance with the long-established laws of heredity, on the one hand, that a physical anomaly existing in the parents is liable to be transmitted to the offspring and, on the other, that the offspring tend to revert to the normal type. Can they also be brought into accord with the more recently discovered laws of Mendelian inheritance?

To apply the principles of Mendelism to deaf-mutism is not easy. In addition to the difficulties that present themselves in the case of any human character—the small number of the offspring and the long intervals between generations—there is a special obstacle in the case of deaf-mutism arising from the fact that deafness is not in itself a physical trait, but is merely the result or symptom of some abnormal condition of the organ of hearing, and that the abnormal conditions producing this result are many and various.

If, however, we exclude all forms of deafness that are due to accident or disease, confining the inquiry strictly to cases that are clearly hereditary (as indicated by the existence of deaf relatives), it seems probable, as Dr. Love concludes, that this form of deaf-mutism may be regarded as a Mendelian trait. The reasons for this view are: (1) In hereditary deafness the amount of deafness, or more correctly speaking the amount of hearing, is a fairly constant quantity; (2) the deafness is due to abnormality of only one part of the ear, viz., the internal ear; (3) the proportion of deaf offspring, as shown in the above table, is very much greater where both parents carry the hereditary germ (as indicated by the possession of deaf relatives on both sides or by the marriage of a deaf person with a relative) than where only one parent is hereditarily deaf.

Hereditary deaf-mutism, from a Mendelian point of view, must be regarded as a recessive and not a dominant character, for it appears in the offspring of many persons who are not themselves deaf and is most frequent among the offspring of consanguineous parents. Whether it is due to the presence or absence of a single factor or more than one, and whether absolute Mendelian ratios can be demonstrated, are questions for future inquiry. The highest percentages of deaf offspring in the above table (30.3 per cent. and 30 per cent.) are suggestive of the Mendelian ratio of 3:1; but one must not attach too much importance to this suggestion, for we do not know to what extent the conditions required to produce the Mendelian ratio existed in the progenitors.

*Consanguinity of Parents.*—Heads of schools for the deaf, observing that a considerable number of their pupils are the children of parents related by blood, generally believe that consanguineous marriages are a frequent cause of deaf-mutism. Of 13,271 pupils of American schools, 1,028, or 7.75 per cent., were the children of first cousins. Of 34,085 deaf persons reported in the census of 1900, 2,525, or 7.4 per cent., were the children of cousins. Unfortunately we do not know the proportion of marriages of first cousins to all marriages, but it is probably considerably less than 7 per cent.; if so, we may conclude that such marriages are more likely to result in deaf offspring than ordinary marriages. The reason is, probably, not that consanguineous marriage in itself is a true cause of deaf-mutism, but that in some families there exists a tendency to deafness, and when two persons belonging to such a family marry, the tendency is transmitted to their offspring with increased intensity, and deaf-mutism is the result. The disastrous effects of deaf-mutes marrying their relatives are shown in the 31 cases above cited. In 18 of these cases one of the partners was a hearing person; 9, or 50 per cent.

of these 18 marriages, resulted in deaf children, and 20, or 30 per cent., of the children born therefrom were deaf. If both partners had been hearing persons, but similarly related, the results would probably have been equally unfortunate. Even when no hereditary tendency to deafness is known to exist in a family, relatives should generally be advised not to marry; for, as Mr. George H. Darwin suggests, no man knows with certainty, until toward the end of life, what ills may lie hidden in his edition of the family constitution.

*Social Circumstances.*—Unfavorable social circumstances, poverty, and ignorance may be classed among the indirect causes of deaf-mutism. It is a matter of common observation rather than of statistical record that most of the pupils in schools for the deaf come from the poorer classes of the community, and it is certainly reasonable to suppose that negligence, damp and overcrowded dwellings, insufficient nourishment, the lack of proper medical treatment, and other evils springing from poverty and ignorance, may combine with more direct causes to produce deafness. The lack of proper medical treatment especially is undoubtedly responsible for much deaf-mutism among the poor. In many cases of deafness caused by syphilis, scarlet fever, measles, catarrhal affections, etc., the deafness might have been averted by proper medical treatment at the right time.

*Mountainous Regions.*—The large percentage of deaf-mutes in Switzerland, as compared with all other countries of which we have statistics (see Extent of Deaf-Mutism, *supra*), and of the more mountainous regions of Switzerland, Austria, France, Spain, and Germany, as compared with the lower and more level districts (45 in 10,000 in Berne, Lucerne, and Wallis, to 24.5 in the whole of Switzerland; 30.6 in Salzburg, Steiermark, and Carinthia, to 9.7 in all Austria; 24.5 in the Alpine departments of France to 6.26 in the whole country; 10.4 in South Germany to 6.05 in North Germany) shows that there must be some influence in mountainous countries which, in some manner, tends to cause deaf-mutism. The opponents of consanguineous marriages charge the result to the kinship of the parents, who are said to be more likely to be related to each other than in the lowlands, on account of the scanty means of communication between different districts; others, who attach much importance to social conditions, ascribe it to the poverty of mountainous regions, and the close, unhealthy houses in which the people live in winter; others to the dampness and coldness of the climate; others to the use of certain waters, which, it is said, are also a cause of the goiter, cretinism, and other anomalies often found in Switzerland in the same families with deaf-mutism. We must await a fuller knowledge of all the causes of deaf-mutism, and of all the circumstances of mountaineers, before we can explain this phenomenon satisfactorily.

*Other Causes.*—Other causes which appear to have some influence in producing deaf-mutism are general debility and alcoholism in one or both of the parents, and influences exerted during pregnancy. It is difficult to prove any of these causes statistically, because, as Hartmann and Mygind have remarked, the reports are often uncertain, and also because we have no statistics as to other large groups of individuals with which to draw comparison. Alcoholism especially has been noted in a good many parents of deaf children, both of those congenitally and of those adventitiously deaf; probably the proportion of persons addicted to drink who have deaf children is greater than the proportion of persons thus addicted is to the community at large. Dr. E. Saint-Hilaire found 46 alcoholic fathers among the 177 fathers of the pupils of the school for the deaf at Asnières, a suburb of Paris; in five cases the mother as well as the father used alcohol to excess. Granting that a connection exists between alcoholism and deaf-mutism, the question still remains whether the cause of the deaf-mutism is alcoholism or a morbid condition of the nervous system of which the alcoholism is a symptom and result.

Fright or some other influence acting on the mind of the mother during pregnancy is frequently assigned by parents or friends as a cause of deaf-mutism, and striking narratives, especially with respect to gesticulating deaf-mutes seen by the mother for the first time during that period, are related in support of the theory. Inasmuch, however, as further inquiry usually brings to light other causes which seem to be adequate, we need not accept this as a true cause. On the other hand, injuries to the mother producing abnormal compression of the embryo, and thus arresting the development of some parts, may possibly sometimes occasion deaf-mutism. Dr. Saint-Hilaire attributes some cases of deafness in illegitimate children to the mother's efforts to conceal her condition by extremely tight lacing during pregnancy.

*Diseases and Accidents.*—Turning to the causes which more unmistakably produce deafness after hearing is known to have existed, statistics show that it so often follows certain diseases as to leave no room for doubt that these diseases may be counted as true causes, though there are perhaps sometimes antenatal influences which combine with these causes to produce the result. The assigned causes of 37,426 cases of deafness reported in the census of 1900, classified, as far as possible, according to the effect produced upon the external ear, the middle ear, and the internal ear respectively, were as follows:

| Causes of deafness. | Number. | Percentage. |
|---|---|---|
| Classified | 18,164 | 48.5 |
| Unclassified | 16,950 | 45.3 |
| Unknown | 2,312 | 6.2 |
| Classified: | | |
| External ear | 207 | 0.6 |
| Impacted cerumen | 71 | 0.2 |
| Foreign bodies in ear | 50 | 0.1 |
| Miscellaneous (external ear) | 86 | 0.2 |
| Middle ear | 10,227 | 27.3 |
| Suppurative | 7,390 | 19.7 |
| Scarlet fever | 4,145 | 11.1 |
| Disease of ear | 1,365 | 3.6 |
| Measles | 953 | 2.5 |
| Influenza | 273 | 0.7 |
| Other (suppurative) | 654 | 1.7 |
| Non-suppurative | 2,836 | 7.6 |
| Catarrh | 1,354 | 3.6 |
| Colds | 580 | 1.5 |
| Other (non-suppurative) | 902 | 2.4 |
| Miscellaneous (middle ear) | 1 | 0.0 |
| Internal ear | 7,730 | 20.7 |
| Labyrinth | 661 | 1.8 |
| Malarial fever and quinine | 439 | 1.1 |
| Other (labyrinth) | 222 | 0.6 |
| Nerve | 6,931 | 18.5 |
| Meningitis | 3,609 | 9.6 |
| Brain fever | 1,744 | 4.7 |
| Typhoid fever | 908 | 2.4 |
| Other (nerve) | 670 | 1.8 |
| Brain center for hearing | 96 | 0.3 |
| Miscellaneous (internal ear) | 42 | 0.1 |
| Unclassified: | | |
| Congenital | 12,607 | 33.7 |
| Old age | 115 | 0.3 |
| Military service | 375 | 1.0 |
| Falls and blows | 1,050 | 2.8 |
| Sickness | 1,002 | 2.7 |
| Fever | 758 | 2.0 |
| Hereditary | 122 | 0.3 |
| Miscellaneous (unclassified) | 921 | 2.5 |
| Total | 37,426 | 100.0 |

In a list of the causes of deafness of 12,380 pupils who have attended American schools for the deaf, meningitis, instead of scarlet fever, stands at the head and scarlet fever comes next. Other causes in this list do not differ greatly from the percentages given above.

*Syphilis.*—Among the diseases producing deaf-mutism there is one of great importance that is not mentioned in either the census returns quoted above nor in the reports of schools. That is congenital syphilis, which Dr. Love regards as the most frequent cause of deafness next to meningitis, scarlet fever, and measles. Indeed it is probably sometimes the cause of the meningitis that results in deafness. Deafness produced by congenital syphilis may be either partial or total; it may be congenital or it may develop during the first, second, or third decade of life. It is sometimes accompanied by total or partial blindness.

*Correlation of Deaf-mutism with Blindness, etc.*—According to the census of 1890, 295 persons in the United States were deaf-mute and blind, 409 deaf-mute and insane, 1,373 deaf-mute and feeble-minded, 62 deaf-mute, blind, and insane, and 137 deaf-mute, blind, and feeble-minded. It is probable that a considerable number of those returned as deaf-mute and feeble-minded were not really deaf, but were mute from mental incapacity; that some of those reported as deaf-mute and blind were persons whose hearing or sight or both had failed in their old age; and that many reported as deaf-mute and insane were uneducated deaf-mutes whose social condition and environment were such as would tend to produce insanity.

There is no doubt, however, that there does really exist in a considerable number of cases a correlation between deaf-mutism and these other misfortunes. Even when deafness alone appears, the other defects referred to are sometimes found in other members of the same family. It is not strange that this correlation should exist, for, as Dr. Love suggests, hereditary deaf-mutism, blindness, epilepsy, and feeble-mindedness probably all have their origin in one and the same division of the fertilized ovum—the epiblast of the blastoderm—which gives rise to the epidermis and its appendages, the great nervous centers, the principal parts of the eye, ear, and nose. Congenital syphilis also is likely to produce these other defects as well as deafness.

This correlation of deaf-mutism with other misfortunes in the same person or in other members of the family has led Saint-Hilaire to regard deaf-mutism as a form of degeneracy, and Féré has observed in the pupils of the Paris Institution and other deaf-mutes who have come under his observation some of the recognized marks of degeneracy. No doubt there are deaf-mutes who may properly be classed as degenerates, but there does not seem to be in the facts presented by these writers any sufficient reason for regarding deaf-mutism in general as a form of degeneracy.

The Prevention of Deaf-mutism.—The census returns of several European countries during the past two or three decades indicate that the proportion of deaf-mutes to the whole population is gradually diminishing. (In the United States unfortunately the deaf have been enumerated in successive censuses with so little uniformity of method, and the returns have varied so irregularly, that it is impossible to ascertain from them whether deafness in this country is diminishing or not.) This diminution is doubtless owing to the increasing skill of physicians in treating the diseases that cause deafness and it suggests the possibility that the time may come when there shall be no more deaf-mutism. Dr. Love has recently made a thorough study of this subject and has reached the conclusion that deaf-mutism is preventable in a large majority of cases. Meningitis, scarlet fever, measles, syphilis—the most frequent causes of non-hereditary deaf-mutism—are all preventable diseases and when they do occur deafness may be averted by prompt and efficient treatment. Sanitary housing conditions; careful and prolonged attention to the ear complications that are liable to follow scarlet fever and measles; the notification and isolation of all cases of meningitis; the notification and immediate treatment of syphilis in mother and child; these are the means by which he believes that deaf-mutism, when it is not hereditary, may be prevented.

The prevention of hereditary deaf-mutism, which happily is much less frequent than adventitious deafness, is a more difficult problem. If hereditary deaf-mutism were the result only of unions in which the parents were themselves hereditarily deaf, there might be some ground for prohibiting such unions by law or even for sterilization, as some eugenists propose; but inasmuch as hearing persons carrying the germ of deafness are as liable to have deaf offspring as are deaf persons, such action would be unjust; while to apply it to all carriers of the germ, whether deaf or hearing persons, would be impracticable, for such carriers are very numerous, the hearing carriers being far more numerous than the deaf carriers. Much, however, can be accomplished by warning the public of the danger that all persons, whether deaf or hearing, who have deaf relatives incur by marrying persons, whether deaf or hearing, who have deaf relatives, and especially the danger such persons incur by marrying persons related to them by blood. Such warnings should be impressed upon the deaf while they are at school and upon their relatives by the school authorities. Physicians also have a responsibility to the public to prevent, as far as lies in their power, marriages that are liable to result in deaf offspring.

Mental Condition and Characteristics.—With respect to mental condition and characteristics, the division of the deaf into several distinct classes, mentioned at the beginning of this article, is of the greatest importance. Semi-mutes, who have acquired an idiomatic use of spoken language before hearing was lost, retain to a greater or lesser degree the modes of thought and mental characteristics of hearing persons. They think in words and express themselves easily and naturally in the language of their childhood. In the course of time, especially if they are not encouraged to use the voice in conversing with others, they may lose their memory of sound and may cease to pronounce words mentally; but even then, if they have learned to read and write, words in their written or printed form will serve them as natural and convenient instruments of thought.

Since semi-mutes, on account of their deafness, cannot, as a rule, be educated in common schools, and their number in any community is usually too small to justify the establishment of special schools for them, they are educated with deaf-mutes, many of the processes of instruction beyond the elementary stage being equally applicable to both classes; but the semi-mute always has a great advantage over his deaf-mute classmate in his command of language. This distinction, though it is often explained by candid teachers, is not always understood by visitors to the school-room; and the public are thus sometimes misled as to the actual attainments of deaf-mutes. In mental vigor, and in the acquisition of general knowledge, the true deaf-mute, notwithstanding he is heavily handicapped in respect to language, will not infrequently surpass the semi-mute; but most of the cases of remarkable facility in composition and of great success in articulation that astonish the undiscriminating public at exhibitions, belong to the class of semi-mutes, as do also nearly

all the deaf persons who have distinguished themselves in later life as authors and poets.

Between the semi-mute and the congenital deaf-mute, but more closely allied with the latter than the former, stands the "quasi-congenital" deaf-mute. He retains no conscious memory of words; he must acquire written language or vocal speech by the same laborious processes as if he had never heard; in his attempts at composition he makes the same curious mistakes as the congenital deaf-mute; and yet it is a fact often observed by teachers that children of this class do learn language more easily and successfully, and adapt themselves more readily to the modes of thought of hearing persons, than those who are born deaf or lose their hearing soon after birth. When we remember how vivid are the impressions of childhood, how full a vocabulary, and how much fuller a comprehension of language as spoken by others, a bright child obtains during the first two or three years of his life, it is not strange if the mental condition of one who loses hearing when he has reached this age is essentially different from that of one who has never heard. The wonder is rather that, of the immense mental and linguistic acquisitions he has made through the sense of hearing, so little appears to remain.

The uneducated deaf-mute who has never heard, or whose hearing has been lost in early infancy, has no knowledge whatever of the language of words. This lack of language is the key to his mental condition and characteristics. He has an intelligent mind; he observes, reasons, and forms conclusions; but his train of thought, being carried on by means of mental pictures and rude gestures, is imperfect and incomplete, while his reasoning, being based upon his own limited range of observation uncorrected by the superior wisdom and wider experience of others, is apt to lead him to erroneous conclusions. Careful inquiries made of educated deaf-mutes with respect to their ideas before instruction have elicited the fact that, although—like young children in general—they usually accept the phenomena of nature as a matter of course, and do not trouble themselves concerning their origin, yet they do sometimes reflect on these subjects and frame for themselves various fanciful explanations of the means by which the more striking natural phenomena are produced; as, for instance, that the wind is blown from a great bellows, that the rain is poured down through small holes in the sky, that snow is ground out like flour from a celestial mill, that thunder and lightning are the discharges of cannon, that the stars are candles or lamps lighted every evening, that death is caused by the medicine administered to the sick person, etc., etc. None seem to have arrived at the idea of the existence of the soul, nor of a God, nor of immortality; and there are only two instances on record in which they have reflected at all upon the origin of the world and its inhabitants. One girl, who had reached the age of fifteen before coming to school, said that she "had tried to think about it, but could not"; she "thought the people came from the South"; and one very intelligent boy, at the age of nine years, having gained from his own observation an idea of the descent from parent to child, the propagation of animals, and the production of plants from seeds, struggled long and earnestly with the question whence came the first man, the first animal, and the first plant; but, like many wiser men, without reaching any satisfactory conclusion.

The deaf-mute very early invents a language of signs sufficient for the expression of the common wants of his every-day life, and if he has intelligent friends who are ready to aid his attempts at the exchange of ideas in this way, or if he associates with other deaf-mutes, this language will be extended and elaborated to a high degree. It becomes his usual mode of thought; and while he may, after long years of effort by his teachers and himself, learn to think more or less in spoken or written words, the language of signs always remains his easiest and most natural method not only of expression but of thought. The language of words written or spoken is for him something strange, foreign, artificial; he may master it as the hearing student masters a foreign tongue, so that he will think in it to some extent, use it with considerable freedom, and read it understandingly and profitably; but, except in very rare cases of peculiar education and environment, the language of gesture is, and always remains, the vernacular of the deaf-mute.

The language of words being a foreign language to the deaf-mute, he is liable, even after years of instruction, to make mistakes in its use. Such mistakes of course become less frequent as his education advances; but the deaf-mute who has never heard, or who has lost his hearing in early infancy, rarely, if ever, acquires such a mastery of language as to employ it in speech or writing with the same readiness and freedom as persons who learn to speak in childhood through the hearing. The peculiarities in his phraseology are sometimes called "deaf-mutisms," and their origin has been ascribed by some writers to the inversions of the sign language; but their main cause, like that of the blunders of foreigners, is merely an incomplete knowledge of the language of words.

The characteristics of an uneducated deaf-mute, especially when in unfavorable social circumstances his natural language of signs has not been developed beyond its most rudimentary stage, are what might be expected. Cut off from communication with his kind, misinterpreting alike the order of nature and the actions of his fellow-men, he is apt to become melancholy, suspicious, treacherous, and cruel. The neglect on the part of parents and friends which, from any motive whatever, allows the deaf-mute child to grow up in this condition, when, as in the United States, the benefits of education are freely offered to all, is simply criminal.

A wisely conducted education, giving the deaf-mute writing or speech as a means of communication, and imparting just views of his relations to God and his fellow men, tends to correct the defects above mentioned, and enables him to take his proper place in the world as an active and useful member of society.

Means of Communication.—*Speech and speech-reading* are now generally taught in American schools for the deaf and some deaf people become very proficient in this means of communication. In some cases, however, owing to mental incapacity, defective vision, or other ineptitude the success attained in these branches is so slight as to be of little if any practical value.

The deaf-mute's natural *language of signs* has been developed and elaborated in schools for the deaf to such a degree that it is capable of expressing abstract ideas and delicate shades of meaning. For the deaf it is so much clearer than speech and so much more rapid than writing or manual spelling that they generally prefer it to any other mode of communication in conversing with one another. They also prefer it for public addresses, for it appeals to their mind and heart more forcibly than the most eloquent spoken words.

The *manual alphabet*, which is much used by the deaf as an adjunct to the sign language, may be readily acquired by any one in less than an hour and is often of great convenience as a means of communicating with the deaf when neither speech nor the sign language is available. A little practice enables one to use it much more rapidly than one can write. The single-hand manual alphabet is generally preferred by the deaf of America.

*Writing* also is always possible as a means of communicating with the educated deaf who are not able to read the lips or when it is important that there should be no misunderstanding of what is said.

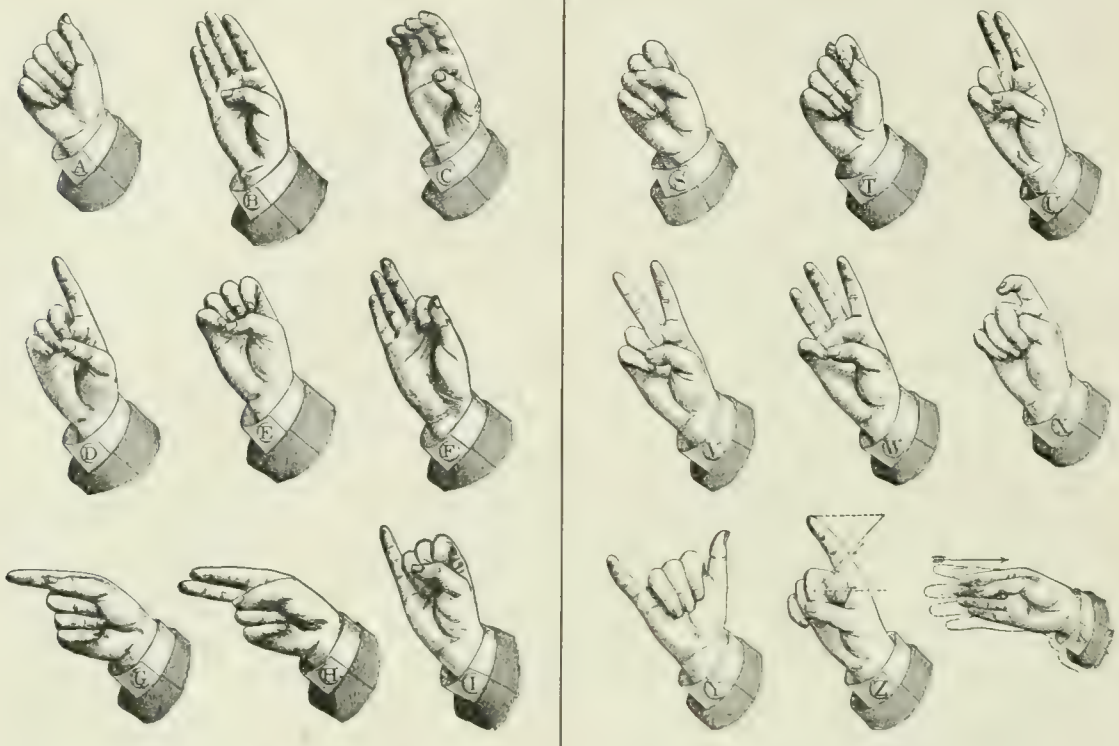


Fig. 1638.—The One-hand Alphabet in General Use.

In the census of 1900 an inquiry was made as to the means of communication ordinarily and usually employed by the deaf. In a majority of cases the replies named two or more of the four methods above specified. Dr. Bell analyzed and classified the returns by an ingenious scheme and the result showed that the varieties reported included all the fifteen possible combinations of the four methods. The following table shows the number and percentage of the deaf who were reported as employing the several methods or combinations of methods:

| Usual methods of communication. | Number. | Percentage. |
|---|---|---|
| Signs, finger spelling, writing, and speech | 3,340 | 09.5 |
| Signs, finger spelling, and writing | 12,617 | 36.0 |
| Signs, finger spelling, and speech | 142 | 00.4 |
| Signs and finger spelling | 983 | 02.8 |
| Signs, writing, and speech | 147 | 00.4 |
| Signs and writing | 361 | 01.0 |
| Signs and speech | 424 | 01.2 |
| Signs | 5,904 | 16.8 |
| Finger spelling, writing, and speech | 317 | 00.9 |
| Finger spelling and writing | 759 | 02.2 |
| Finger spelling and speech | 46 | 00.1 |
| Finger spelling | 262 | 00.7 |
| Writing and speech | 450 | 01.3 |
| Writing | 231 | 00.7 |
| Speech | 9,078 | 25.9 |
| Number reported | 35,061 | 100.0 |

Probably those who were reported as using signs alone were the uneducated or poorly educated deaf; those who used signs along with other methods of communication were the average pupils and graduates of our schools; those who employed speech alone were mostly those who had acquired it in the natural way through the ear and retained it after hearing was lost, but in this class there were also 1,805 persons with whom deafness occurred under the age of five, 659 of whom were born deaf.

The number reported as employing finger spelling alone and writing alone was very small, but the

number who used these methods of communication along with others was large, as is shown by the following table, which gives the number and proportion of those who were reported as employing each of the four methods of communication, either alone or along with other methods:

| Method of communication. | Deafness occurred under 20. | |
|---|---|---|
| | Number. | Percentage. |
| Signs | 23,512 | 75.9 |
| Finger spelling | 18,238 | 58.9 |
| Writing | 17,951 | 58.0 |
| Speech | 10,235 | 33.1 |
| Number reported | 30,964 | |

Morbidity.—Since the maladies that cause deafness are in some cases the result of an imperfect physical constitution, and in others leave a previously sound constitution debilitated and impaired, we should expect to find the percentage of morbidity in persons of this class higher than among hearing persons. We have few records on this point except those of our schools, and the latter not in a statistical form; but it is the general testimony of the heads of schools that their pupils, as a rule, enjoy excellent health—quite as good as the average health of hearing children. This is probably due to the regular habits, wholesome food, well-ventilated rooms, good sanitary arrangements, and out-of-door exercise afforded by institution life, which counteract any unfavorable constitutional tendencies that may exist.

Tuberculosis was formerly regarded as a disease to which deaf-mutes were peculiarly liable, since statistics collected by Porter and Peet in this country, Wilde in Ireland, and Müller in Germany showed that a large proportion of deaths were due to this cause, but within recent years tuberculosis has not been observed to be especially prevalent among the deaf. The mortality from this cause in former times was probably due to bad sanitary conditions and to infection.

It is sometimes asserted that the lungs of deaf-mutes are ill developed on account of their lack of exercise in speech. But, aside from the fact that deaf children do generally use their voices considerably, making a great variety of sounds, the expansion of the lungs in respiration, as Hartmann says, really suffices for their proper development. A careful examination of the lungs of the students of Gallaudet College at Washington, with a view to cautioning them against violent gymnastic exercises in case of pulmonary weakness, showed only one out of fifty with any tendency in that direction.

Mortality.—There are no comparative tables on a scale sufficiently extended to enable us to form a definite conclusion as to the mortality of deaf-mutes as compared with hearing people. In Denmark during the years 1879–88 the mortality among adult deaf-mutes corresponded pretty nearly to the mortality among the laboring classes in Copenhagen, whose death rate was the highest of any class in Denmark; a result which Mygind attributes to their unfavorable social and sanitary conditions. The total numbers, however, were too small to be conclusive. At first thought it might be supposed that deaf-mutes are more liable than hearing persons to fatal accidents in the street, on the railway, etc., on account of their inability to hear warnings of danger; but this liability is probably offset by their greater habit of caution in such places. It is to be hoped that the necessary statistics for determining the rate of mortality of deaf-mutes may soon be afforded, for at present some insurance companies refuse to accept risks on their lives and others charge them more than the usual rates.

Marriage.—Since the education of deaf-mutes has become general, marriage among them has ceased to be rare, especially in America. Of 27,924 pupils who attended American schools for the deaf up to the year 1890, 6,460, or 23 per cent., married. Of 37,223 deaf persons reported in the census of 1900, 10,630, or 28.5 per cent., were married, widowed, or divorced.

Marriages of deaf-mutes seem to be slightly less productive than ordinary marriages. The proportion of 3,078 marriages of the deaf in America without offspring was 14.1 per cent., and the average number of children to each mother was 2.61.

In 72 per cent. of the marriages of the deaf recorded in America both of the partners were deaf. As has been shown above under "Heredity," marriages of this kind, unless both partners are hereditarily deaf, are not more liable to result in deaf offspring than those in which one of the partners is deaf and the other a hearing person; that they are more likely to be happy marriages, owing doubtless to the strong bond of mutual fellowship growing out of the similar condition of husband and wife, the ease and freedom with which they communicate with each other, and the identity of their social relations and sympathies, is indicated by the statistics of divorces and separations. In the marriages of the deaf in America, where both of the partners were deaf, the proportion of the divorces and separations reported was 2.5 per cent.; where one of the partners was deaf and the other a hearing person, the proportion was 6.5 per cent.

In the case of deaf-mutes whose deafness is not hereditary there is little, if any, danger that deafness will reappear in the offspring, provided they marry persons, whether deaf or hearing, who have no deaf relatives. The liability to deaf offspring when either or both of the partners is hereditarily deaf has been mentioned above under "Heredity."

Occupations.—Uneducated deaf-mutes can and do perform unskilled labor, but the competition here is so great, and they are at so much disadvantage in various ways as compared with hearing persons, that, though they are sometimes self-supporting, they are often more or less a burden upon their friends or upon the community.

With educated deaf-mutes the case is very different. In all of the large American schools the importance of industrial instruction is fully recognized and several hours of each day are devoted to this purpose. The occupations taught are, for the boys, baking, barbering, basket-making, blacksmithing, book-binding, book-keeping, bricklaying, broom-making, cabinet-making, calcimining, carpentry, cementing, chair-making, coopery, engineering, engraving, farming, floriculture, gardening, glazing, harness-making, horticulture, mattress-making, painting, paper-hanging, plastering, photography, plumbing, printing, shoemaking, sign-painting, stone-laying, tailoring, typewriting, and wood-turning; for the girls, cooking, domestic and ornamental sewing, both with and without the machine, dress-making, ironing, knitting, millinery, shirt-making, tailoring, and the folding and stitching of sheets for the book-binder. Instruction in clay-modelling, drawing, decorating, etc., enables some of both sexes to engage in various pursuits of industrial art and in pure art. In some instances the pupils are made thorough masters of their trades while at school, so that they immediately command remunerative positions upon graduating; and even in the greater number of cases in which they merely

acquire the principles of a trade, familiarity with the use of tools, dexterity, and habits of industry, they find it much easier to master the business afterward, or to learn some new trade, than would be possible if no attention had been paid to industrial education.

Of the 23,272 deaf persons who were reported in the census of 1900 as twenty years of age and over, 11,670, or 50.1 per cent., were gainfully employed. The percentage rightfully entitled to be regarded as self-supporting is even larger than this, for the chief occupation reported by married females ("keeping house") is not included in the census report among gainful occupations. The list of occupations pursued by educated deaf-mutes includes not only the industries above mentioned as taught at school, but almost every pursuit that does not require the actual use of hearing and speech. The great majority are engaged in various branches of skilled industry; some are artists, or workers in industrial art; while among the more intelligent and highly educated, especially those who have enjoyed the advantages of the College at Washington, are many teachers of the deaf, several clergymen preaching to the deaf, and several editors, publishers, merchants, government clerks, architects, real estate agents, bankers, inventors, chemists, and lawyers.

There are very few, if any, professional mendicants among the deaf. The numerous beggars and peddlers who appeal to the sympathy of the public by exhibiting written or printed cards saying "I am deaf and dumb" are generally impostors with unimpaired hearing and speech. It is not always easy for the average citizen to detect the fraud, but an educated deaf person or a teacher of the deaf can readily do so. The American Association of the Deaf is making vigorous efforts to put a stop to these impositions which bring upon the deaf a discredit that is entirely unmerited.

Legal Rights and Responsibilities.—Under the Justinian Code, deaf-mutes who could not read and write were classed with the insane and idiotic, and had therefore no legal rights nor responsibilities. A better comprehension of their mental condition has led to considerable modification of their legal status, so far at least as their rights are concerned. It has been decided repeatedly, both in England and America, that an uneducated deaf-mute who possesses sufficient intelligence to express his ideas, wishes, and intentions by signs can make contracts, execute deeds, dispose of property by gift or by testament, and give evidence in court. The degree of intelligence and facility of communication can usually be determined by the testimony of acquaintances or of experienced teachers of the deaf.

The uneducated but not unintelligent deaf-mute who commits crime against property—usually theft—is generally and properly held responsible for the act; but in the case of serious crime against the person—as, for instance, homicide under the provocation of cruelty—his moral and legal responsibility is not so easy to determine. In such cases, which have been unhappily frequent in proportion to the number of this class of persons, judges and juries, especially in view of the death penalty, have naturally shrunk from the decision that the deaf-mute without any education was morally and legally responsible, and he has either through an appeal by his counsel to the old law classing deaf-mutes with the insane and idiotic escaped trial altogether, or through the sympathy or the disagreement of the jury been acquitted.

Educated deaf-mutes who can communicate with others orally or by writing occupy the same position before the law as hearing persons.

Schools for the Deaf in the United States.—The first permanent school for the deaf in the United States was established at Hartford, Conn., in 1817 by Rev. Thomas Hopkins Gallaudet, LL. D. There are now 154 schools containing (November 10, 1912) 13,193 pupils. Sixty-four of these schools, with 10,837 pupils, are public residential schools supported by the several States; of the remaining pupils, 981 are in public day schools and 274 in denominational and private schools. The various methods of instruction used in these schools may be defined as follows:

I. *The Manual Method.*—Signs, the manual alphabet, and writing are the chief means used in the instruction of the pupils, and the principal objects aimed at are mental development and facility in the comprehension and use of written language. The degree of relative importance given to these three means varies in different schools; but it is a difference only in degree, and the end aimed at is the same in all.

II. *The Manual Alphabet Method.*—The manual alphabet and writing are the chief means used in the instruction of the pupils, and the principal objects aimed at are mental development and facility in the comprehension and use of written language. Speech and speech-reading are taught to all of the pupils in the school (the Western New York Institution) recorded as following this method.

III. *The Oral Method.*—Speech and speech-reading, together with writing, are made the chief means of instruction, and facility in speech and speech-reading, as well as mental development and written language, is aimed at. There is a difference in different schools in the extent to which the use of natural signs is allowed in the early part of the course, and also in the prominence given to writing as an auxiliary to speech and speech-reading in the course of instruction; but they are differences only in degree, and the end aimed at is the same in all.

IV. *The Auricular Method.*—The hearing of semi-deaf pupils is utilized and developed to the greatest possible extent, and, with or without the aid of artificial appliances, their education is carried on chiefly through the use of speech and hearing, together with writing. The aim of the method is to graduate its pupils as hard-of-hearing speaking people instead of deaf-mutes. There is no school in which this method is used exclusively; but it is employed with some of the pupils in thirty-eight schools in the United States.

V. *The Combined System.*—Speech and speech-reading are regarded as very important, but mental development and the acquisition of language are regarded as still more important. It is believed that in many cases mental development and the acquisition of language can be best promoted by the Manual or the Manual Alphabet method, and, so far as circumstances permit, such method is chosen for each pupil as seems best adapted for his individual case. Speech and speech-reading are taught where the measure of success seems likely to justify the labor expended, and some of the pupils are taught wholly or chiefly by the Oral method or by the Auricular method.

The following table gives all the schools for the deaf in the United States existing in the year 1912, with their location, date of opening, and methods of instruction:

A.—Public Schools (not Including Day-schools).

| Name. | Location. | Date of opening. | Methods of Instruction. |
|---|---|---|---|
| Alabama School for the Deaf | Talladega, Ala. | 1858 | Combined. |
| Arizona, University of, Department for the Deaf | Tucson, Ariz. | 1912 | Oral. |
| Arkansas Deaf-mute Institute | Little Rock, Ark. | 1868 | Combined. |
| California Institution for the Education of the Deaf and the Blind | Berkeley, Alameda Co., Cal. | 1860 | Combined. |
| Colorado School for the Deaf and the Blind | Colorado Springs, El Paso Co., Colo. | 1874 | Combined. |
| Columbia Institution for the Deaf { A. Kendall School for the Deaf | Kendall Green, Washington, D. C. | 1857 | Combined. |
| Columbia Institution for the Deaf { B. Gallaudet College | Kendall Green, Washington, D. C. | 1864 | Combined. |
| Connecticut { American School for the Deaf | Hartford, Conn. | 1817 | Combined. |
| Connecticut { Mystic Oral School for the Deaf | Mystic, Conn. | 1870 | Oral. |
| Florida School for the Deaf and the Blind | St. Augustine, Fla. | 1885 | Combined. |
| Georgia School for the Deaf | Cave Spring, Ga. | 1846 | Combined. |
| Idaho State School for the Deaf and the Blind | Gooding, Idaho | 1906 | Combined. |
| Illinois School for the Deaf | Jacksonville, Ill. | 1846 | Combined. |
| Indiana State School for the Deaf | Indianapolis, Ind. | 1844 | Combined. |
| Iowa School for the Deaf | Council Bluffs, Iowa | 1855 | Combined. |
| Kansas School for the Deaf | Olathe, Johnson Co., Kansas | 1861 | Combined. |
| Kentucky School for the Deaf | Danville, Boyle Co., Ky. | 1823 | Combined. |
| Louisiana State School for the Deaf | Baton Rouge, La. | 1852 | Combined. |
| Maine School for the Deaf | Portland, Me. (79-91 Spring St.) | 1876 | Combined. |
| Maryland { School for the Deaf and Dumb | Frederick, Md. | 1868 | Combined. |
| Maryland { School for the Colored Blind and Deaf (*a*) | Overlea, Baltimore Co., Md. | 1872 | Combined. |
| Massachusetts { Boston School for the Deaf | Randolph, Mass. | 1899 | Oral. |
| Massachusetts { Clark School for the Deaf | Northampton, Mass. | 1867 | Oral. |
| Massachusetts { New England Industrial School for Deaf-mutes | Beverly, Mass. (113 Elliott St.) | 1879 | Oral. |
| Michigan School for the Deaf | Flint, Mich. | 1854 | Combined. |
| Minnesota School for the Deaf | Faribault, Rice Co., Minn. | 1863 | Combined. |
| Mississippi Institution for the Deaf | Jackson, Miss. | 1854 | Combined. |
| Missouri School for the Deaf | Fulton, Callaway Co., Mo. | 1851 | Combined. |
| Montana School for Deaf and Blind | Boulder, Montana | 1893 | Combined. |
| Nebraska School for the Deaf | Omaha, Neb. | 1869 | Combined. |
| New Jersey School for the Deaf | Trenton, N.J. (Chest't and Ham'n Aves.) | 1883 | Combined. |
| New Mexico Asylum for the Deaf and the Dumb | Santa Fé, N. M. | 1885 | Combined. |
| New York { New York Institution for the Instruction of the Deaf and Dumb | New York, N. Y. (*b*) | 1818 | Combined. |
| New York { Central New York Institution for Deaf-mutes | Rome, Oneida Co., N. Y. | 1875 | Combined. |
| New York { Western New York Institution for Deaf-mutes | Rochester, N. Y. (1545 St. Paul St.) | 1876 | Man. Alph. |
| New York { Northern New York Institution for Deaf-mutes | Malone, Franklin Co., N. Y. | 1884 | Combined. |
| New York { Institution for the Improved Instruction of Deaf-mutes | New York, N.Y. (904-922 Lexington Av.) | 1867 | Oral. |
| New York { Le Couteulx St. Mary's Institution for the Improved Instruction of Deaf-mutes | Buffalo, N. Y. (2253 Main St.) | 1862 | Combined. |
| New York { St. Joseph's Institute for the Improved Instruction of Deaf-mutes | West Chester, N. Y. (*c*) | 1869 | Combined. |
| New York { Albany Home School for the Oral Instruction of the Deaf | Pine Hills, Albany, N.Y. (98 N. Pine Av.) | 1889 | Oral. |
| North Carolina { State School for the Deaf and Dumb | Morganton, Burke Co., N. C. | 1894 | Combined. |
| North Carolina { State School for the Blind and the Deaf | Raleigh, N. C. | 1845 | Combined. |
| North Dakota School for the Deaf and Dumb | Devils Lake, Ramsey Co., North Dak. | 1890 | Combined. |
| Ohio State School for the Deaf | Columbus, Ohio | 1829 | Combined. |
| Oklahoma { School for the Deaf | Sulphur, Oklahoma | 1898 | Combined. |
| Oklahoma { Industrial Inst. for the Deaf, Blind, and Orphans of the Colored Race | Taft, Oklahoma | 1909 | Manual. |
| Oregon School for Deaf-mutes | Salem, Oregon | 1870 | Combined. |
| Pennsylvania { Pennsylvania Institution for the Deaf and Dumb | Mt. Airy, Philadelphia, Pa. | 1820 | Oral. |
| Pennsylvania { Western Pennsylvania Institution for the Instruction of the Deaf and Dumb | Edgewood Park, Allegheny Co., Pa. | 1876 | Combined. |
| Pennsylvania { Pennsylvania Oral School for the Deaf | Scranton, Pa. | 1883 | Oral. |
| Pennsylvania { Home for the Training in Speech of Deaf Children (*d*) | Philadelphia, Pa. (*e*) | 1892 | Oral. |
| Rhode Island Institute for the Deaf | Providence, R. I. (520 Hope St.) | 1877 | Oral. |
| South Carolina Institution for the Education of the Deaf and the Blind | Cedar Spring, S. C. | 1849 | Combined. |
| South Dakota School for the Deaf | Sioux Falls, Minnehaha Co., South Dak. | 1880 | Combined. |
| Tennessee Deaf and Dumb School | Knoxville, Tenn. | 1845 | Combined. |
| Texas { School for the Deaf | Austin, Texas | 1857 | Combined. |
| Texas { Deaf, Dumb, and Blind Institute for Colored Youth | Austin, Texas | 1887 | Combined. |
| Utah School for the Deaf | Ogden, Utah | 1884 | Combined. |
| Vermont, The Austine Institution for the Deaf and Blind | Brattleboro, Vt. | 1912 | Oral. |
| Virginia { School for the Deaf and the Blind | Staunton, Va. | 1839 | Combined. |
| Virginia { School for Colored Deaf and Blind Children | Newport News, Va. | 1909 | Manual. |
| Washington State School for the Deaf | Vancouver, Wash. | 1886 | Combined. |
| West Virginia Schools for the Deaf and the Blind | Romney, Hampshire Co., W. Va. | 1870 | Combined. |
| Wisconsin State School for the Deaf | Delavan, Walworth Co., Wis. | 1852 | Combined. |

(*a*) This School is a department of the Maryland School for the Blind. (*b*) Fort Washington Avenue and West 163d Street. (*c*) This Institution has three branches: one situated at West Chester, another at Fordham (772 East 188th Street), and another at Brooklyn (113 Buffalo Ave.). (*d*) Home for the Training in Speech of Deaf Children before they are of School Age. (*e*) Belmont and Monument Avenues. (*f*) The Superintendent is Mrs. Clara M. H. McGuigan, who resides at 6018 Drexel Road, Philadelphia, Pa.

B.—Public Day-schools.

| | Name. | Location. | Date of opening. | Methods of instruction. |
|---|---|---|---|---|
| California | Los Angeles Day-school for the Deaf | Los Angeles, Cal. (*i*) | 1899 | Oral. |
| | Oakland Day-school Oral Classes | Oakland, Cal. (*g*) | 1898 | Oral. |
| | Sacramento Day-school for the Deaf | Sacramento, Cal. (10th and I Sts.) | 1904 | Oral. |
| | San Francisco Oral School for the Deaf | San Francisco, Cal. (*e*) | 1901 | Oral. |
| Georgia | Atlanta Day-school for the Deaf | Atlanta, Ga. (Ashby St. School) | 1912 | Combined. |
| Illinois | Chicago (*a*): Bernhard Moos Public Day-school for the Deaf | California Ave., near Wabansia Ave. | 1908 | Oral. |
| | Chicago (*a*): Burr Public Day-school for the Deaf | Ashland Ave. and Wabansia St. | 1898 | Oral. |
| | Chicago (*a*): Dore Public Day-school for the Deaf | Harrison, near Halstead St. | 1875 | Oral. |
| | Chicago (*a*): Hammond Public Day-school for the Deaf | 21st Pl. and California Ave. | 1902 | Oral. |
| | Chicago (*a*): Holden Public Day-school for the Deaf | 31st and Loomis Sts. | 1905 | Oral. |
| | Chicago (*a*): Jirka Public Day-school for the Deaf | 17th St. between Loomis and Laughlin | 1909 | Oral. |
| | Chicago (*a*): Kozminski Public Day-school for the Deaf | Cor. 54th St. and Ingleside Ave. | 1896 | Oral. |
| | Chicago (*a*): Normal Practice Public Day-school for the Deaf | 67th St. and Stewart Ave | 1905 | Oral. |
| | Chicago (*a*): Ogden Public Day-school for the Deaf | Chestnut and North State Sts. | 1896 | Oral. |
| | Chicago (*a*): Phil Sheridan Public Day-school for the Deaf | Escanaba Ave. and 90th St. | 1910 | Oral. |
| | Chicago (*a*): Seward Public Day-school for the Deaf | 46th St. and Hermitage Ave. | 1897 | Oral. |
| | Rock Island Day-school for the Deaf | Rock Island, Ill. (*h*) | 1901 | Oral. |
| Massachusetts | Horace Mann School | Boston, Mass. (178 Newbury St.) | 1869 | Oral. |
| Michigan | Bay City, Hard-of-hearing Department of Public Schools | Bay City, Mich. | 1901 | Oral. |
| | Calumet Day-school for the Deaf | Calumet, Mich. | 1902 | Oral. |
| | Detroit Day-school for the Deaf | Detroit, Mich. (Abbot St., near Eighth.) | 1894 | Oral. |
| | Grand Rapids Oral School for the Deaf and Hard-of-hearing | Grand Rapids, Mich. (*b*) | 1898 | Oral. |
| | Houghton Day-school for the Deaf | Houghton, Mich. | 1908 | Oral. |
| | Iron Mountain Day-school for the Deaf | Iron Mountain, Mich. | 1906 | Oral. |
| | Ironwood Day-school for the Deaf | Ironwood, Mich. | 1903 | Oral. |
| | Jackson Day-school for the Deaf | Jackson, Mich. | 1912 | Oral. |
| | Kalamazoo Day-school for the Deaf | Kalamazoo, Mich. (919 W. North St.) | 1904 | Oral. |
| | L'Anse Day-school for the Deaf | L'Anse, Mich. | 1912 | Oral. |
| | Manistee Day-school for the deaf | Manistee, Mich. (Union School) | 1904 | Oral. |
| | Marquette Day-school for the Deaf | Marquette, Mich. | 1907 | Oral. |
| | Saginaw Oral Day-school for the Deaf | Saginaw, Mich. (S. Weadock Ave.) | 1901 | Oral. |
| | Sault Ste. Marie Day-school for the Deaf | Sault Ste. Marie, Mich. | 1906 | Oral. |
| | Traverse City Day-school for the Deaf | Traverse City, Mich. (Boardman School) | 1904 | Oral |
| Missouri | Gallaudet School | St. Louis, Mo. (*c*) | 1878 | Combined. |
| New Jersey | Jersey City Public Day-school for the Deaf | Jersey City, N. J. (Coles St.) | 1910 | Oral. |
| | Newark School for the Deaf | Newark, N. J. (James St. School) | 1912 | Oral. |
| New York | Public School 47, Manhattan | New York, N. Y. (225 East 23d St.) | 1908 | Oral. |
| | Public School 162, Classes for the Deaf, Brooklyn | Brooklyn, N. Y. (St. Nicholas Ave.) | 1910 | Oral. |
| Ohio | Ashtabula Day-school for the Deaf | Ashtabula, O. (Tyler Ave. School) | 1903 | Oral. |
| | Cincinnati Oral School | Cincinnati, O. (Main and Woodward Sts.) | 1886 | Oral. |
| | Cleveland Public School for the Deaf | Cleveland, Ohio (2380 East 55th St.) | 1892 | Oral. |
| | Conneaut Oral School | Conneaut, O. (Main and School Sts.) | 1909 | Oral. |
| | Dayton School for the Deaf | Dayton, O. (Steele High School Bldg.) | 1899 | Oral. |
| | Toledo Day-school for the Deaf | Toledo (Walbridge and Broadway Ave.) | 1911 | Oral. |
| Oregon | Portland Day-school for the Deaf | Portland, Ore. (E. 12th and Ankeny Sts.) | 1908 | Oral. |
| Washington | Seattle Public Day-school for the Deaf | Seattle, Wash. (20th Ave. and Thos. St.) | 1906 | Oral. |
| | Tacoma Day-school for the Deaf | Tacoma (St. Helen's Ave. and 5th St.) | 1908 | Oral. |
| Wisconsin | Antigo Day-school for the Deaf | Antigo, Wis. | 1906 | Oral. |
| | Appleton Day-school for the Deaf | Appleton, Wis. (6th Ward Bldg.) | 1896 | Oral. |
| | Ashland Day-school for the Deaf | Ashland, Wis. (7th Ave. and 2d St.) | 1898 | Oral. |
| | Black River Falls School for the Deaf | Black River Falls, Wis. (High School Building.) | 1897 | Oral. |
| | Bloomington Day-school for the Deaf | Bloomington, Wis. | 1906 | Oral. |
| | Eau Claire Day-school for the Deaf | Eau Claire, Wis. (2d Ward Bldg.) | 1895 | Oral. |
| | Fond du Lac Day-school for the Deaf | Fond du Lac, Wis. (Grant School) | 1895 | Oral. |
| | Green Bay Day-school for the Deaf | Green Bay, Wis. (Ward School) | 1897 | Oral. |
| | La Crosse Day-school for the Deaf | La Crosse, Wis. (6th and Vine Sts.) | 1899 | Oral. |
| | Madison Day-school for the Deaf | Madison, Wis. (Doty School) | 1908 | Oral. |
| | Marinette Day-school for the Deaf | Marinette, Wis. (Ward School Bldg.) | 1895 | Oral. |
| | Marshfield School for the Deaf | Marshfield, Wis. | 1912 | Oral. |
| | Milwaukee School for the Deaf | Milwaukee, Wis. (*d*) | 1898 | Oral. |
| | Mineral Point School for the Deaf | Mineral Point, Wis. | 1912 | Oral. |
| | New London Day-school for the Deaf | New London, Wis. | 1906 | Oral. |
| | Oshkosh School for the Deaf | Oshkosh, Wis. | 1895 | Oral. |
| | Platteville Day-school for the Deaf | Platteville, Wis. | 1906 | Oral. |
| | Racine Day-school for the Deaf | Racine, Wis. (McMynn School) | 1900 | Oral. |
| | Rice Lake Day-school for the Deaf | Rice Lake, Wis. | 1907 | Oral. |
| | Sheboygan Day-school for the Deaf | Sheboygan, Wis. (2d Ward School) | 1894 | Oral. |
| | Stevens Point Day-school for the Deaf | Stevens Point, Wis. | 1905 | Oral. |
| | Superior Day-school for the Deaf | West Superior, Wis. | 1897 | Oral. |
| | Wausau Day-school for the Deaf | Wausau, Wis. (Scott and 6th Sts.) | 1890 | Oral. |

(*a*) The first Public Day-school for the Deaf in Chicago was opened in 1875 in a rented building on Van Buren Street. (*b*) 164 North Division Ave. (*c*) 3435 Henrietta Street. (*d*) Cor. Seventh and Prairie Streets. (*e*) Golden Gate Ave., between Pierce and Scott Streets. (*g*) Lafayette School, 17th and West Streets. (*h*) Lincoln School, 7th Ave. and 22d Street. (*i*) Primary Department, Grand Ave. School; Intermediate Department, 16th Street School.

C.—Denominational and Private Schools.

| Name. | | Location. | Date of Opening | Methods of instruction. |
|---|---|---|---|---|
| California | St Joseph's Home for the Deaf | Oakland, Cal. (4002 Telegraph Ave.) | 1895 | Combined. |
| Georgia | Miss Arbaugh's School | Macon, Ga | 1912 | Oral |
| Illinois | Ephpheta School for the Deaf | Chicago, Ill. (40th and Belmont Ave.) | 1884 | Combined. |
| | Mr. Gallagher's Night School for the Adult Deaf | Chicago, Ill. (5357 Kenmore Ave.) | 1904 | Manual. |
| | The McCowen Homes for Deaf Children | Chicago, Ill. (c) | 1883 | Oral |
| Louisiana | Deaf-mute Institute of the Holy Rosary | Chinchuba, St. Tammany Parish, La. | 1890 | Combined. |
| Maryland | Home School for Little Deaf Children | Kensington, Md. | 1908 | Oral. |
| | F. Knapp's English and German Institute | Baltimore, Md. (851 and 853 Hollins St.) | 1877 | Oral. |
| | St. Francis Xavier's School for the Deaf | Irvington, Md. (Woodland Ave.) | 1897 | Oral. |
| Massachusetts | The Sarah Fuller Home for Little Deaf Children | West Medford, Mass. (93 Woburn St.). | 1888 | Oral. |
| Michigan | Evangelical Lutheran Deaf-mute Institute | North Detroit, Wayne Co., Mich. | 1873 | Combined. |
| Missouri | Immaculate Conception Institute for the Deaf | St. Louis, Mo. (901 N. Garrison Ave.) | 1885 | Combined. |
| New York | Reno Margulies School for Children with Defective Hearing | New York, N. Y. (534 W. 187th St.) | 1901 | Oral. |
| | The Wright Oral School | New York, N. Y. (a) | 1894 | Oral. |
| Ohio | Notre Dame School for the Deaf | Cincinnati, O. (321 East Sixth Street) | 1890 | Oral. |
| | Miss Breckinridge's School | Cincinnati, O. (b) | 1906 | Oral. |
| Pennsylvania | De Paul Institute for Deaf-mutes | Pittsburgh, Pa. (d) | 1908 | Oral. |
| | The Swarthmore School and Kindergarten for the Deaf | Swarthmore, Pa. (c) | 1901 | Oral. |
| South Dakota | Black Hills School for the Deaf | Lead, So. Dak. (514 Main St.) | 1911 | Oral. |
| Wisconsin | St. John's Institute for Deaf-mutes | St. Francis, Wis. | 1876 | Combined. |

(a) 1, 2, and 3 Mt. Morris Park, West. (b) 8 The Navarre, Gilbert and Yale Aves. (c) Corner Chester Road and Ogden Ave. (d) Cranford Ave., Brookline. (e) 6550 Yale Ave. and 6756 Normal Avenue.

*School Age.*—There is a difference of opinion among experienced teachers as to the best age for sending deaf children to school. On the one hand, such children have so much to learn as compared with hearing children that their education ought to be begun as early as possible; on the other, there are obvious objections to taking them away from their homes—as in the great majority of cases is necessary in order that they may receive proper instruction—while they are still very young. The decision must depend largely upon the circumstances of the individual, and the facilities offered by the State in which he resides. Where the term of instruction afforded by the State is limited to six or seven years, and where children are surrounded by favorable influences at home, probably ten or twelve is the best age for them to be sent to school, since experience has shown that the six or seven years following that age are those in which the most can be accomplished for the physical, mental, and moral development of the deaf-mute; but where, as is the case in some States, there is no limit to the term of instruction, where proper provision is made for the care and teaching of the little children by kindergarten or Montessori methods apart from the older pupils, and especially where the home influences are bad, it is desirable to send them as young as five or six years of age. From five or six to ten they will probably make less progress at school than from ten to fourteen; but if, in addition to those four or five years under ten, they remain six or seven years longer, they will be able to acquire a much fuller mastery of the language of their fellow-men, and to reach a far more advanced stage of education in all respects, than if their education had not been begun until the years of early childhood were passed.

*Residential Schools and Day Schools.*—Within recent years laws have been passed in several States providing for the establishment of day schools for the deaf, the town or city desiring such a school providing the necessary room or rooms and the State paying a certain sum *per capita* for the children taught. This has the advantage of enabling the pupils to live at home while receiving instruction, but experience has shown that the education thus given is less efficient and successful than in residential schools. The evil influences that surround many deaf children at home, the temptations of the street out of school hours, the danger of accidents in going to and from school, the interruptions to progress from tardiness and absence, the difficulty of classification arising from small numbers, and the lack of facilities for industrial instruction, make the results much less satisfactory than in the well-organized residential school, where the influences of the workshop, the playground, and the evening study hour all combine with those of the schoolroom to promote the proper development and education of the child.

*Private Instruction at Home.*—It has been said that "the best deaf-mute school is a school of one pupil," but the statement is not to be received without some qualification. In order to attain a mastery of spoken or written language the more individual attention the deaf child receives the better, and in this respect private instruction at home has a decided advantage over class instruction at school. On the other hand, the child taught alone at home, and thus lacking the stimulus of association with others placed on an equal footing with himself, is apt to become listless in study and melancholy in disposition. The best advice, therefore, to be given to parents whose means enable them to provide a private teacher is this: Obtain a competent tutor or governess for your child at three or four years of age. Let the efforts of this teacher for seven or eight years be devoted almost wholly to giving the child language, articulation, and speech-reading by the natural intuitional method, which imitates as closely as the nature of the case allows the manner in which hearing children learn to speak, and let the teacher's efforts be heartily seconded by all the other members of the family. When the child is ten or twelve years old send him to school to pursue other branches of study and complete his education. The command of idiomatic language acquired by the home training is something that could not be imparted at school, while the moral and intellectual development received at school could not be attained at home.

Intelligent parents and friends, whose pecuniary circumstances do not allow them to employ a private teacher, can themselves do a great deal in the way of preparing their deaf children for school life by forming in them habits of order and obedience, by calling their attention to the movements of the lips and vocal organs when talking to them, and by teaching them the use of the pencil and pen, counting, and common words in their written forms. If the child already

possesses speech gained before hearing was lost, great efforts should be made to retain the speech and to cultivate the habit of reading the lips of others. Poor speech, however, is likely to result unless instruction in articulation is given by a trained teacher. If any hearing exists, it should be utilized in practice, the aid of the hearing tube, trumpet, and acousticon should be tried, and whichever instrument proves most effective should be employed. In all cases the deaf child should be governed with the same firmness as his hearing brothers and sisters. While due allowance should be made for his inability to understand, and he should be protected as far as possible from the teasing of playmates, he can and should be taught strict obedience to parents, and due respect for the rights of others.

Higher Education.—The standard of education in schools for deaf-mutes at the present day corresponds in general to that of the common schools—an education fitting the pupil for intelligent citizenship. But there are some among the deaf who are capable of advancing beyond this standard and preparing themselves for scientific and literary pursuits. The United States makes provisions for the wants of this class in Gallaudet College, established by Congress at Washington, D. C., in the year 1864, through the efforts of Edward M. Gallaudet, Ph.D., LL. D., who was its president for forty-six years. This college affords a course of training corresponding to that of American colleges in general, with such modifications as seem desirable in view of the peculiar needs of the deaf, and confers upon its graduates the usual academic degrees. Of the students who have been connected with the college a large number are now engaged in teaching, several are editors and publishers, others are in the civil service of the Government, one is a lawyer practising in the Supreme Court of the United States, one is at the head of large assaying works in Chicago, several are clergymen preaching to the deaf, and nearly all are occupying positions of a higher grade than would have been possible without the educational advantages conferred by the college course.

Religious Work for Adults.—The moral and religious instruction given in most of the American schools for the deaf is of an unsectarian character, the pupils being advised by their teachers to connect themselves during their vacations, or after leaving the schools, with the churches to which their parents belong. Adult deaf-mutes, however, can generally derive much more pleasure and profit from special services in the sign language than from ordinary religious exercises, and in places where their numbers are sufficiently large to form a congregation, the holding of such services is entirely practicable. The Rev. Thomas Gallaudet, D.D., of New York, established a church for deaf-mutes in that city in 1852, and religious services in the sign language are now held weekly in most of the large cities of the United States, and at less frequent intervals in many other places. The Episcopal Church is most active in this work; the Lutherans, Methodists, Baptists, Roman Catholics, and Israelites also have churches or missions for the deaf. In all these missions, except the Roman Catholic, most of the clergymen in charge are themselves deaf, and there are a large number of deaf laymen who assist in missionary work. In connection with the religious organizations there usually exist benevolent and relief societies, and in some cases literary and social unions.

Organizations.—There are three important national organizations devoted to the welfare of the deaf in the United States. (1) The Convention of American Instructors of the Deaf, which was organized in 1850 and incorporated by Congress in 1897, aims chiefly to promote the education of the deaf. Its membership is composed of teachers of the deaf without respect to methods. Its President is Dr. E. M. Gallaudet, of Hartford, formerly President of Gallaudet College. Its organ is the *American Annals of the Deaf* published at Washington, D.C., under the direction of the Conference of Superintendents and Principals of American Schools for the Deaf. It meets triennially and its Proceedings are published by Congress. (2) The National Association of the Deaf, organized in 1880 and incorporated in 1900, is open to deaf adults. It holds triennial meetings and is active in promoting the educational and industrial welfare of the deaf. Its President is Mr. Olaf Hanson, of Seattle, Washington. (3) The American Association to Promote the Teaching of Speech to the Deaf, organized and incorporated in 1890 and liberally endowed by Dr. Alexander Graham Bell, has for its object to aid schools for the deaf in their efforts to teach speech and speech-reading. It holds meetings triennially, assists in the maintenance of a normal class and summer training school for teachers at Northampton, Mass., and carries on the work of the Volta Bureau for the Increase and Diffusion of Knowledge Relating to the Deaf at Washington, D. C. This Bureau, established and endowed by Dr. Bell, publishes the *Volta Review* and other works relating to the deaf, maintains a library, collects statistics, and in other ways endeavors to carry out the purpose indicated by its name. The President of the Association is Dr. Caroline A. Yale, of Northampton, Mass.

Edward Allen Fay.

**Deafness.**—See *Hearing, Defective.*

**Dearborn Spring.**—Windsor County, Vermont.

Post-office.—Woodstock.

Access.—Via a branch line of railroad from White River Junction, Vermont (twelve miles west).

This spring, formerly known as the "Old Sanderson Spring," is located in Woodstock about three miles from the famous Woodstock Inn. A fine level road leads to within three-quarters of a mile of the spring, a good hill road covering the remainder of the distance. The spring was discovered about 1830, and soon gained a considerable reputation among the neighboring farmers for its good effects in dyspepsia, kidney disorders, and skin diseases. The water was analyzed about 1850 by one of the professors in the Woodstock Medical School. The analysis has been lost, but it is said that, among other ingredients, magnesia, bicarbonate of calcium, iron, and sulphur were found. In 1890 the spring passed into new hands, and the owner had it excavated to the bed-rock, thoroughly cleaned and stoned up to within four feet of the surface, and then tiled and carefully protected from the surface water. The tiling was extended upward through a tight floor and a building erected over the spring, with easy facilities for raising the water. A new analysis was made and the water was found to resemble that of the Poland Springs of Maine. The location is now enclosed in a beautiful park, with avenues leading to the spring. Its elevation is 900 feet above Woodstock Park and about 1,600 feet above sea level. The atmosphere is pure and invigorating, and a number of fine views may be had from the park surrounding the spring. The water of the spring maintains an even temperature throughout the year, which fact would indicate that it proceeds from a great depth. It is icy cold when the temperature of the surrounding air stands at 90° F. in the shade.

Emma E. Walker.

**Death Certification.**—In England, as in this country in the early days, persons dying were buried

N. B.—WRITE PLAINLY, WITH UNFADING INK—THIS IS A PERMANENT RECORD. Every item of information should be carefully supplied. AGE should be stated EXACTLY. PHYSICIANS should state CAUSE OF DEATH in plain terms, so that it may be properly classified. Exact statement of OCCUPATION is very important. See instructions on back of certificate.

Form 4 V S.

**1 PLACE OF DEATH**

County.....

Town.....
or
Village.....
or
City..... (No.....,.....St.; .....Ward)

**2 FULL NAME**

New York State Department of Health
BUREAU OF VITAL STATISTICS

**STANDARD CERTIFICATE OF DEATH**
**STATE OF NEW YORK**

Registered No.....

[If death occurred in a hospital or institution, give its NAME instead of street and number]

**PERSONAL AND STATISTICAL PARTICULARS**

| 3 SEX | 4 COLOR OR RACE | 5 SINGLE, MARRIED, WIDOWED, OR DIVORCED (Write the word) |
|---|---|---|
| | | |

6 DATE OF BIRTH
....., 1.....
(Month) (Day) (Year)

7 AGE
.....yrs. .....mos. .....ds.
If LESS than 1 day, how many ---hrs. or ---min.?

8 OCCUPATION
(a) Trade, profession, or particular kind of work .....
(b) General nature of industry, business, or establishment in which employed (or employer) .....

9 BIRTHPLACE (State or country)

PARENTS

10 NAME OF FATHER

11 BIRTHPLACE OF FATHER (State or country)

12 MAIDEN NAME OF MOTHER

13 BIRTHPLACE OF MOTHER (State or country)

14 THE ABOVE IS TRUE TO THE BEST OF MY KNOWLEDGE

(Informant).....

(Address).....

15
Filed ....., 191.....
REGISTRAR

**MEDICAL CERTIFICATE OF DEATH**

16 DATE OF DEATH
....., 191.....
(Month) (Day) (Year)

17 I HEREBY CERTIFY, That I attended deceased from
....., 191....., to....., 191.....
that I last saw h..... alive on....., 191.....,
and that death occurred, on the date stated above, at.....m.
The CAUSE OF DEATH* was as follows:

.....
.....
.....
.....(Duration).....yrs.....mos.....ds.
Contributory.....
(Secondary)
.....(Duration).....yrs.....mos.....ds.

(Signed) ....., M.D.
....., 191..... (Address).....

*State the DISEASE CAUSING DEATH, or, in deaths from VIOLENT CAUSES, state (1) MEANS OF INJURY; and (2) whether ACCIDENTAL, SUICIDAL, or HOMICIDAL.

18 LENGTH OF RESIDENCE (FOR HOSPITALS, INSTITUTIONS, TRANSIENTS, OR RECENT RESIDENTS).
At place of death ..... yrs. ..... mos. ..... ds. In the State ..... yrs. ..... mos. ..... ds.
Where was disease contracted, if not at place of death?.....
Former or usual residence .....

19 PLACE OF BURIAL OR REMOVAL

21 DATE OF BURIAL
....., 191.....

20 UNDERTAKER

ADDRESS

Burial or Transit } Permit issued by..... Date of Issue.....

Standard Death Certificate.

in the churchyard of the village or city church which they attended and records were kept by the sexton or clergy connected with the same, these records, however, showed only the name and age, and not the cause of death.

When cemeteries came into vogue records of deaths were made by their officers of the name, age, etc., without any cause of death being given. These records were voluntary and hence subject to errors. It became necessary at last to enact laws for the registration of all deaths, and the provisions of the laws of different states and countries are quite similar.

In England, according to a law passed in 1836 and amended later, personal information of every death must be given to the registrar of the district, within five days of its occurrence, by the nearest relatives of the deceased, present at the death or in attendance at the last illness. A registered physician during the last illness must give a certificate of the cause of death, failing to do so, is liable to a penalty for neglect, or imprisonment for giving a false one. Deaths are also certified by coroners. No record is made of stillbirths in England, either as births or as deaths.

In 1893 the House of Commons appointed a committee to secure an improvement to existing conditions, and they made the following recommendations: (1) That in no case should a death be registered without a certificate of the cause of death signed by a registered medical practitioner or by a coroner after inquest, or in Scotland by a procurator fiscal. (2) That in each sanitary district a registered medical practitioner should be appointed as public medical certifier of the cause of death in cases in which a certificate from a medical practitioner in attendance is not forthcoming. (3) That a physician in attendance should be required, before giving a certificate of death, personally to inspect the body; but if on the ground of distance or for other sufficient reason he is unable to make this inspection himself, he should obtain and attach to the certificate of the cause of death a certificate signed by two persons, neighbors of the deceased, verifying the fact of death. (4) That medical practitioners should be required to send certificates of death to the registrar, instead of sending them to the representatives of the deceased. (5) That a form of a certificate of death should be prescribed, and that in giving a certificate a medical practitioner should be required to use such form. (6) That it should be a penal offence to bury or otherwise dispose of a body, except in time of epidemic, without an order from the registrar stating the place and mode of disposal, which order, after it has been

## REVISED UNITED STATES STANDARD CERTIFICATE OF DEATH

[Approved by U. S. Census and American Public Health Association]

**Statement of occupation.**— Precise statement of occupation is very important, so that the relative healthfulness of various pursuits can be known. The question applies to each and every person, irrespective of age. For many occupations a single word or term on the first line will be sufficient, e. g. *Farmer, Physician, Stenographer, Compositor, Architect, Locomotive engineer, Civil engineer, Stationary fireman,* etc. But in many cases, especially in industrial employments, it is necessary to know (*a*) the kind of work and also (*b*) the nature of the business or industry, and therefore an additional line is provided for the latter statement; it should be used only when needed. As examples: (*a*) *Spinner,* (*b*) *Cotton mill;* (*a*) *Salesman,* (*b*) *Grocery;* (*a*) *Foreman,* (*b*) *Automobile factory.* The material worked on may form part of the second statement. Never return "Laborer," "Foreman," "Manager," "Dealer," etc., without more precise specification, as *Day laborer, Farm laborer, Laborer — Coal mine,* etc. Women at home, who are engaged in the duties of the household only (not paid *Housekeepers* who receive a definite salary), may be entered as *Housewife, Housework,* or *At home,* and children, not gainfully employed, as *At school* or *At home.* If the occupation has been changed or given up on account of the DISEASE CAUSING DEATH, state occupation at beginning of illness. If retired from business, that fact may be indicated thus: *Farmer (retired, 6 yrs.).* For persons who have no occupation whatever, write *None.*

**Statement of cause of death.**— Name, first, the DISEASE CAUSING DEATH (the primary affection with respect to time and causation), using always the same accepted term for the same disease. Examples: *Cerebrospinal fever* (the only definite synonym is "Epidemic cerebrospinal meningitis"); *Diphtheria* (avoid use of "Croup"); *Typhoid fever* (never report "Typhoid pneumonia"); *Lobar pneumonia, Bronchopneumonia* ("Pneumonia," unqualified, is indefinite); *Tuberculosis of lungs, meninges, peritoneum,* etc. *Carcinoma, Sarcoma,* etc., of ..... (name origin; "Cancer" is less definite; avoid use of "Tumor" for malignant neoplasms); *Measles; Whooping cough; Chronic valvular heart disease; Chronic interstitial nephritis,* etc. The contributory (secondary or intercurrent) affection need not be stated unless important. Example: *Measles* (disease causing death), *29 ds.; Bronchopneumonia* (secondary), *10 ds.* Never report mere symptoms or terminal conditions, such as "Asthenia," "Anaemia" (merely symptomatic), "Atrophy," "Collapse," "Coma," "Convulsions," "Debility" ("Congenital," "Senile," etc.), "Dropsy," "Exhaustion," "Heart failure," "Hemorrhage," "Inanition," "Marasmus," "Old age," "Shock," "Uremia," "Weakness," etc., when a definite disease can be ascertained as the cause. Always qualify as "PUERPERAL *septicemia,*" "PUERPERAL *peritonitis,*" etc., all diseases resulting from childbirth or miscarriage. State cause for which surgical operation was undertaken. For VIOLENT DEATHS state MEANS OF INJURY and qualify as ACCIDENTAL, SUICIDAL, or HOMICIDAL, or as *probably* such, if impossible to determine definitely. Examples: *Accidental drowning; Struck by railway train — accident; Revolver wound of head — homicide; Poisoned by carbolic acid — probably suicide.* The nature of the injury, as fracture of skull, and consequences (e. g., *sepsis, tetanus*) may be stated under the head of "Contributory." (Recommendations on statement of cause of death approved by Committee on Nomenclature of the American Medical Association.)

### AN ACT IN RELATION TO THE PUBLIC HEALTH, CONSTITUTING CHAPTER FORTY-FIVE OF THE CONSOLIDATED LAWS

§ 22. **Vital statistics.**—"It shall be the duty of the physician last in attendance upon any person who may die to fill out a certificate of the death and the probable cause, and duly certify to same and deliver the certificate to the local registrar of vital statistics within twenty-four hours after the death occurs. In case an inquest is required by law, the coroner or the coroner's physician shall fill out the said certificate, and if no inquest is required and no physician has been in attendance, the certificate shall be filled out, setting forth the circumstances and probable cause of death, by some reputable person known to the officer issuing the burial or transit permit, and the said person shall also make affidavit to the facts set forth in the certificate of death."

§ 23. **Burial and burial permits.**—"Every undertaker, sexton or other person having charge of any corpse, shall procure a burial permit from the local registrar with whom the certificate of death has been filed, or the health officer of the town or municipality and there shall be no burial or removal of a corpse until a permit for such burial or removal has been obtained."

Standard Death Certificate. (Reverse.)

acted upon, should be returned to the registrar who issued it. (7) That it should be made an offence to retain a dead body unburied or otherwise legally disposed of beyond a period not exceeding eight days, except by permission of a magistrate. (8) That the practice of burial in pits or common graves should be discontinued. (9) That still-births which have reached the stage of development of seven months should be registered upon the certificate of a registered medical practitioner, and that it should not be permitted to bury or otherwise dispose of the still-birth until an order for burial has been issued by the registrar. (10) That, subject always to the discretion of the Crown office, the result of precognitions taken by procurators fiscal in Scotland, or the precognitions themselves, should be communicated to the representatives of the deceased when application is made for the same.

In Denmark every death is reported to the parish clerk, and to the clergyman of the parish where it occurred, and is included in the parish register, whether the deceased belonged to the parish or not. No burial can take place before a medical man, or an official qualified to inspect corpses, has issued a certificate.

In Austria no one can be buried before death is officially registered.

Each commune nominates a "Beschauer" who must be either a physician or a surgeon, whose duty it is to examine whether the person is really dead, whether there is evidence of violent death, or whether death was caused by an infectious disease. If death is only apparent, measures must at once be taken to restore animation, and a certificate must not be given in such case till decomposition has begun. If the deceased has had medical care, the attending physi-

cian must make a certificate of death and send it to the registrar.

The laws for registering deaths in Germany are very similar to those of the United States.

The reasons for recording in an accurate and careful manner the death of a person are self-evident, among them being the following: Questions of property rights are often settled by reference to the death record. In settling claims to life insurance an official certificate of death is required. Death certificates settle many disputed questions in regard to pensions. In searching family records they are of value in a genealogical way. In the detection of crime they often prove of great value. They are of value also in showing the extent of disease, whether it is general or sporadic, and whether local or not, and of much importance in the study of disease.

The growth of the "registration area" as it is termed by the Bureau of the Census, is rapidly increasing, and it will be only a few years, before all the States will have uniform laws in regard to death certification. The States included in the registration area for deaths for 1911 are the following: California, Colorado, Connecticut, Delaware, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Utah, Vermont, Washington, Wisconsin, and the District of Columbia; in all of these certificates of death are required by law. Thirty-eight cities in the non-registration States require the filing of certificates of death.

The City of New York Department of Health was created by an act of the Legislature in 1866, and since that time the law has required that certificates of death be filed with the Department of Health. Before that time, the law provided that the remains of no one could be interred unless certificates of death were surrendered to the superintendents or keepers of cemeteries. These certificates of death were in turn delivered to what were known as "city inspectors," who in many instances were engaged in various lines of business, unconnected with their official position. These inspectors filed all certificates of death received by them, and these certificates go back to the year 1798.

The Sanitary Code of the Department of Health of the City of New York requires physicians to report to the Bureau of Records all deaths occurring in their practice within thirty-six hours. "No person shall make, prepare, deliver, or issue any false certificate, statement or report of a death, or any such certificate, statement or report, which is not in accordance with the facts of the death; all certificates, statements, and reports of deaths shall be signed by the person purporting to make the same, and no person shall sign or forge the name of another to any such certificate, statement, or report."

*Transportation of Dead Bodies.*—The Sanitary Code provides that a dead body is not allowed to be carried or conveyed, in any manner, from, through, into, or within the city of New York, without a permit therefor from the Board of Health. The proper coupon for that purpose, attached to any such permit, when issued, shall be preserved and returned to the Department of Health, as its regulations may require, by the proper officer or person on each boat or vessel, and by the proper person in charge of any train of cars or vehicle on which any such body may be carried from said city. No transit permit shall be granted for the removal or burial of the remains of any person who may have died in the city of New York, unless a certificate of death, made out upon a blank form furnished by the Board of Health and signed by a physician upon whom has been conferred the degree of Doctor of Medicine, be filed in the Bureau of Records of the Department of Health.

The retaining or exposing of a dead body or of any human being to the peril or prejudice of the life or health of any person is not allowed. No person shall allow to be retained unburied the dead body of any human being for a longer time than four days, or where death has resulted from smallpox, diphtheria, scarlet fever, yellow fever, typhus fever, plague, Asiatic cholera, or measles, for a longer time than twenty-four hours after death of such person, without a permit from the sanitary superintendent or an assistant sanitary superintendent; this permit shall specify the length of time during which such body may be retained unburied. This does not apply to bodies in any public morgue in the city of New York.

WILLIAM OLIVER MOORE.

**Death, Modes of.**—Life, whether systemic or molecular, depends upon the proper performance of the functions of circulation and respiration; so death, whether the result of disease, of violence, or of senile decay, is due ultimately to the cessation of these functions.

The causes which result in the permanent suspension of circulation and respiration operate directly upon their mechanism, or remotely through the nerve centers which regulate their action. So important indeed to the proper continuance of these functions is the maintenance of an uninterrupted action of the nerve centers of organic life that it is customary to adopt the classification of Bichat and to speak of death beginning at the heart, death beginning at the lungs, and death beginning at the head. For practical purposes this is sufficiently accurate, and it must be admitted that any attempt at a more definite classification is merely theoretical. The phenomena attending each of these modes of dissolution are at least sufficiently distinct to merit separate consideration. Bloch, in his elaborate work on death ("Vom Tode," 1910) has expanded these three modes of death into the following: death by the heart, the brain, the lungs, the kidneys, and the blood, and finally senile death. To the preceding he adds separately all the modes of violent death.

CESSATION OF THE CIRCULATION may be sudden or gradual. The former is witnessed in deaths from syncope and shock; the latter, in those from asthenia. The chief force in the maintenance of the circulation is the normal difference in pressure of the blood in the arteries and veins. Any influence, therefore, that overcomes this difference will cause the circulation to stop. As the maintenance of this blood pressure is due chiefly to the action of the heart, the lesions that produce a fatal interruption of it are found for the most part in that organ. They may be found also in the vessels.

*In the Heart.*—When, from the occurrence of any organic or structural lesion, the heart is rendered no longer capable of propelling its contents into the arteries, the circulation is obliterated and death ensues. The movements of the heart may be suddenly and permanently arrested also by either direct central impulses, as by a gunshot injury, a blow upon the head, or such violent emotion as of fright, joy, or grief; by such direct or reflex impressions as those resulting from a blow upon the lower chest or epigastrium, or from the rupture of abscesses, cysts, or the gravid uterus; by the action of corrosive poisons on the mucous membrane of the stomach, or even by the ingestion of cold liquids in excess or when the body is in an overheated condition. Crile's recent experimental research leads him to the conclusion that collapse or death from violence applied upon the lower chest or abdomen is due mainly to the loss of rhythmic contraction in consequence of the irritation of such violence exerted on the heart muscle itself; that the solar plexus may be disregarded as a factor in it, and that the vagal terminal mechanism in and near the heart may contribute to it in a minor degree. Ac-

cording to Bloch, in none of the above conditions, save when the heart is actually diseased, is that organ primarily at fault; all the activities outside the organ which cause its failure are best classed under violent deaths, even those of psychical origin.

Syncope may be transient, however, as in fainting. There is then a momentary cessation of the heart's action, producing an anemia of the cerebral centers, resulting in a brief period of unconsciousness and apparent death.

In a fatal syncope the individual suddenly turns pale, a cold sweat manifests itself, he becomes dizzy, the pupils dilate, vision becomes dim, the pulse slow, irregular, flickering, and in an instant life is gone. Or the individual may suddenly become pale, make two or three convulsive gasps, and drop dead. When the death is a little less sudden, as in fatal cases of hemorrhage, or when the perforation of an intestinal ulcer takes place, we may observe great restlessness, tossing to and fro, labored respirations, muttering delirium, and, as the scene closes, single or repeated convulsions. Many authors prefer to call fatal syncope a death by the brain.

*In the Vessels.*—When the cause of a sudden failure of the circulation is situated in the blood-vessels, it generally proves to be a rupture of their coats and the rapid reduction of blood pressure by the resulting hemorrhage. A condition closely allied to this sometimes results from an extreme dilatation of the blood-vessels of a single region. The most notable example of this is seen in the state of collapse that follows severe blows upon the abdomen, in which case the abdominal vessels are so distended as virtually to remove the greater part of the blood from the general circulation, and the heart soon ceases to beat from a lack of its normal stimulus. The individual is then said to die of shock. Shock differs from syncope in that the victim may for some time retain his consciousness; there may, however, be associated with shock a syncope due to the reflex inhibition of the heart, in which instance we have combined the symptoms of each. Shock, like syncope, may be transient, the vitality being gradually regained after a longer or shorter period of great depression.

*A gradual failure of the circulation* is the usual termination of a large number of diseases, particularly those of a chronic character. The heart ceases then on account of a failure of its own contractile power. This may result from degenerations of the muscular fibers, produced by continued high temperature, senile, fatty, or atrophic changes, the action of the microorganisms of the infectious diseases, or of the poisons which they develop, or from such toxic sedatives as aconite, digitalis, and tobacco. In this category are classed also deaths from cholera, acute peritonitis, and such wasting affections as phthisis, diabetes, and cancer, as well as inanition and exposure to intense cold.

In this mode of death, the most prominent symptoms are great muscular debility and a feeble, rapid pulse. The intellect may remain clear to the last; but this, as well as the presence or absence of many other symptoms, must depend largely on the character of the disease upon which the death ensues. Bloch would assign some of these affections to "death from the blood."

Cessation of the Respiration.—Death from this cause is known as death by apnea or asphyxia, and may be sudden or gradual.

*Sudden failure of the respiration* is due to a number of influences operating within or without the respiratory organs. The former class includes all obstructions and occlusions of these organs and all paralyses of their muscles as a result of injury or disease, local or central in character. Causes external to the respiratory organs include all obstructions by foreign bodies or by pressure upon any part of the respiratory passage, as in suffocation, strangulation by hanging or drowning, and the action of noxious gases.

The phenomena attending this mode of death are violent efforts at respiration, followed, we are told, by sensations of pleasure and a brief period of remarkable clearness of intellect. The expiratory efforts become violent, unconsciousness and convulsions or a few irregular twitchings of the muscles supervene, the face becomes swollen and cyanotic, the eyeballs protrude; then follows a period of relaxation, interrupted by occasional deep inspirations which finally become spasmodic gasps, and last of all the heart stops. In Bloch's classification most respiratory deaths come under "violence."

*A gradually fatal apnea* is a common result of disease. It is produced by any morbid process which gradually obliterates the lumen of the respiratory passages, *e.g.* papillomata and other neoplasms of the larynx, edema of its mucous membrane, false membranes of the trachea and bronchi, edema of the lungs, and the pneumonic exudation. Failure of the respiration is occasionally the prominent symptom in death from phthisis (catarrhal pneumonia), and it may result from the pressure of large abdominal tumors or ascites.

Individuals dying in this manner exhibit much the same series of symptoms as those whose death is more sudden, but the struggle is less pronounced.

Death from Central Paralysis.—Paralysis of the vital nerve centers, or "death beginning at the head," operates by causing a failure of the circulation or respiration. Diseases, whether primary or secondary, and injuries located in the cerebrum or the cerebellum, may result fatally through extension of the inflammation to the pons or medulla or through the production of abnormal pressure upon them. Deaths from electric shock, and lightning stroke belong to this class. Such poisons as the toxins, ptomaïns, and leucomaïns, and certain drugs, especially the narcotics, impress, as a rule, both cerebral and spinal centers and, when in sufficient quantity, ultimately overcome respiration and circulation.

The most prominent symptom indicative of approaching death from this cause is unconsciousness, or coma, when death is not instantaneous. All reflex movements soon cease; the respiration becomes stertorous, gradually more slow and labored, and at last stops, tranquilly or after convulsive manifestations.

Finally, it should be remembered that the instances in which a death can be clearly traced to the failure of a single group of organs is the exception and not the rule. On the contrary, it will generally be observed that with the ebbing of life, the failure of one system follows so closely upon that of another as to render it extremely difficult to determine which of the vital functions is the last to cease. Death beginning at the lungs may be delayed by the employment of artificial respiration, death beginning at the head may for a time yield to the influence of appropriate remedies; but when the heart has been stilled no human power can restore it to action.

Death from the Kidneys (Uremia).—Bloch states that we can say nothing about death by the heart, lungs, or brain as the site of incipient death that cannot be said of the kidneys as well. When an acute nephritis develops, life is at once menaced; the kidneys are badly diseased and also cause mischief in most of the other organs. The kidney death (uremia) is *sui generis*. It can kill almost instantly a man in apparent health. Ordinarily, of course, uremia represents a slow poisoning.

Death from the Blood.—Bloch uses this term more vaguely. Whatever, like some poisons, destroys the blood corpuscles, *e.g.* pernicious anemia and sepsis with its hemolytic qualities, may come under this head. So would cholera, which dehydrates the blood.

Other conditions readily suggest themselves. There is no typical blood death, but death often begins in that fluid. Many of the chronic blood dyscrasias represent slow deaths—in cancer for example.

Death in the Aged.—In addition to death in the old from ordinary causes, and the typical senile death likened to falling quietly asleep, Bloch cites many concrete examples of death characteristic for the aged. Instead of being the result of senile weakness death may occur after some critical episode. It is in this sort of death that the "last words" are often readily heard. Some succumb quickly after expressing their belief in prompt recovery; others die when assured that they are getting better. Events of the most commonplace character, a spoken word, etc., may be enough to cause the fatal collapse. Death in such cases is sudden and unexpected.

James M. French.
Edward Preble.

**Death, Physiological Theories of.**—Living things, in the forms most familiar to us, at least, all grow old and die. We infer that this fate is universal with something of the same certainty with which we prophesy that a stone thrown into the air at any spot whatsoever will fall back to the earth's surface. On the other hand, it is equally a commonplace of observation that the death of the individual does not mean the death of the race, and, inasmuch as every living thing is directly sprung from a preceding form —*omne vivum e vivo*—we may assume that the continuity of life has never been interrupted, and never will be. If the environment remains as favorable in the future as it has been in the past, living things will continue in unbroken succession for all time. From this standpoint we may speak justly of living matter as possessing immortality, or, at least, potential immortality, since it has unlimited powers of propagation. It is one of the final aims of biological speculation to reconcile these two apparently paradoxical properties of living matter; to furnish a satisfactory hypothesis that shall explain the occurrence of old age and death in the individual, and at the same time account for the possibility of unending existence for the race that is implied in the fact of reproduction.

In speculations of this character we must, moreover, keep clearly in mind that forms of living matter are not stable, in the same sense that forms of dead matter are. A given animal exists for a period of five years; but we are all perfectly well aware that no portion of the living substance of this animal has necessarily remained actually the same throughout this time; *i.e.* the atoms of C, H, O, N, S, P, that constituted the living matter in the beginning, may have been replaced very early by others brought in with the food. What has remained unchanged through the individual's life has been, on the physiological side, a form of activity, and, on the morphological and chemical side, a material substratum of a practically definite composition. However familiar this fact may be, it is, after all, the great distinctive feature of life—or rather, of living matter. We express in the single word assimilation, or nutrition, that property which most distinctly separates living matter from dead. As long as any particle of matter is in the living form, just so long has it the creative power of converting dead food into living substance like itself. Throughout its period of existence there is a steady stream of dead matter coming to it to be rearranged into the living form, and an equally continuous outflow of dead material that had once been in the living form. Nothing can make this conception clearer than Huxley's simile of the whirlpool at Niagara—which fits so well as an illustration of the ever-changing particles that make up the unchanging form of life. From this point of view we may say that living matter is never actually the same, yet it must be evident that, in respect of any given mass of that body which we call protoplasm, it can reproduce itself only in its offspring by transmitting a portion of its actual substance. The formation of a new organism from this transmitted germ is therefore, from a chemical standpoint, no more a creation of a new being or of new living material than is the continued existence of the parent form throughout its period of natural life.

As far as the mere external phenomena of senility are concerned they may be observed and recorded. In the human being this has been done with more or less care. The coming on of the signs of old age in the different tissues, the rate of its normal development, and the conditions that hasten or retard its development, are known to a certain extent, though they have not been investigated with the carefulness of detail that scientific exactness requires. We cannot expect any solid advance in our knowledge of the development of old age until the statistics, which may be determined by experiment and observation, have been recorded. The superficial signs of old age are spoken of usually in the text-books of physiology. In the old, the bones become more brittle because of a continually increasing excess of deposits of inorganic salts; the cartilages become more rigid and calcareous for the same reason; the elasticity of the lens of the eye decreases, bringing on imperfect accommodation; the muscles atrophy and lose their physiological mobility, as shown by the lessened vigor of their contractions and their diminished elasticity; the nuclei of the nerve cells decrease in size and show other signs of deterioration; the hairs lose their pigment, etc. It is important to notice that these signs of deterioration in the machinery of life do not make their appearance first during or after the period of maturity, but begin to develop from the time of birth, or possibly before. At ten years of age the near point of distinct vision is 7 centimeters from the eye, at twenty it has lengthened to 10 centimeters, at forty years of age it is 22 centimeters, at sixty years it is 100 centimeters, and so on. The long-sightedness of old age begins to develop in early childhood, and results physiologically from a continual diminution in the elasticity of the lens. We obtain similar facts if we measure the rate of growth of the body throughout life. According to the somewhat unreliable statistics of Quetelet, the average male child weighs at birth $6\frac{1}{2}$ pounds. At the end of the first year it will weigh $18\frac{1}{2}$ pounds, a gain of 12 pounds. At the end of the second year it will weigh 23 pounds, a gain of only $4\frac{1}{2}$ pounds. And so on to full maturity the rate of increase each year falls rapidly. If we measure the rate of growth by the increase in height instead of by the increase in weight, we find that in the first year the gain is 148 millimeters, in the second year it has fallen to 93 millimeters, in the third to 72 millimeters, from the twentieth to the twenty-fifth year it averages 12 millimeters, and from the twenty-fifth to the thirtieth year only 0.8 millimeter, while in extreme old age it becomes a negative quantity.

In a valuable paper Minot has given the results of a laborious research upon the growth of guinea-pigs, which show much more clearly and accurately the same general fact of a decrease in the rate of growth beginning shortly after birth. Minot bases his figures upon observations taken daily. He defines the term "rate of growth" with an exactness not hitherto employed, in that he calls attention to the fact that usually, in considering the rate of increase, the actual increment at different periods is given instead of the proportionate increment. In other words, if an animal in successive periods gains in absolute quantities only the same amount in weight or height, its rate of growth is in reality decreasing, since proportionately to the weight of the whole animal the increase has been less and less. Making use of his short periods of

twenty-four hours, and expressing the rate of growth as the fraction of weight added during that period, he finds that, after the animal recovers from a short post-natal retardation of growth, the rate of growth diminishes during life, at first rapidly, and afterward more slowly. The curve, however, is not by any means a regular one, the steady decline is marked by irregular ascents, the most notable and regular of which is the acceleration at the time of puberty. The general statements made above may be summarized as follows: Beginning with the fertilization of the ovum the rate of growth in stature and weight increases to a maximum which, according to some observers, is reached at the fifth month of intrauterine life, and thenceforward declines more or less uniformly until the period of puberty at which time a small acceleration occurs, giving a second maximum to the curve. After this prepubertal acceleration the curve continues to fall to the zero point which is reached between the twentieth and the thirtieth years. The period of youth or of growth is then past. Thenceforward the body is able by means of its nutritive processes to maintain only the status quo during the period of adult life. That is to say, it can replace the waste of tissues, but cannot, speaking generally, produce new living tissue. During middle age this balance is maintained completely, but in old age there is obviously a failure to keep a perfect equilibrium, as indicated by the actual diminution in weight and stature which occurs. That changes of a retrogressive or senile character are occurring in reality throughout the whole period of adult life is indicated by the increasing death-rate observed with advancing age. As expressed in Gompertz's law it would seem, after the fiftieth year at least, that the death-rate increases in goemetrical proportion to the increase in years. For each ten years of life the death-rate is doubled, as follows:

| Age period. | Death rate. | |
|---|---|---|
| | Male. | Female. |
| 55–65 | 33.3 | 28.1 |
| 65–75 | 68.3 | 60.0 |
| 75–85 | 147.4 | 133.3 |
| 85 | 308.6 | 281.9 |

It would seem as though some substances or processes essential to the protection of the organism disappear during this period at a rate expressed by this law. It follows from these facts that what we may call the creative power of growth, or better, the creative power of assimilation, which measures the capacity of living matter to form matter like itself, decreases steadily from birth. Like a stone projected upward, the initial velocity begins to fall from the outstart. As the height to which the stone travels may be taken as a measure of the force with which it was thrown, so the length of life in any individual may be taken as a measure of the power or capacity of assimilation with which the germ of that individual started its career.

To mankind as individual organisms old age and death are inevitable, but it is interesting to inquire what may be considered the longest possible life under the most favorable conditions this world is likely to afford. In considering this question it is convenient to accept the distinction made by Ray Lankester between average specific (or actual) longevity and potential longevity. By specific longevity is meant the expectation of life of a normal individual at birth. This expectation is governed by two opposing factors, the innate constitutional properties of his protoplasm and the adverse environmental conditions, such as disease, accident, etc. In civilized countries at present this specific longevity may be reckoned as equal to forty-five or fifty years, and there is reason to believe that if we made full use of the knowledge possessed at present in the field of preventive medicine, ten or fifteen years might be added. By potential longevity is meant the duration of life which would be manifested under ideal conditions of environment. Since ideal conditions cannot be provided for man it is not possible to estimate how long the average life would extend when not cut short by disease or accident. An approximation can be made, however, by ascertaining from the records the longest times recorded for exceptional cases. If we put aside the oldest accounts on the ground of uncertainty as to the unit of time, and make our estimates on the basis of comparatively modern statistics, we may put the maximum age as lying somewhere between one hundred and twenty and one hundred and eighty years. Perhaps the most celebrated case of longevity is that of Thomas Parr, an account of whose life, together with the results of a postmortem examination made by Harvey, may be found in the third volume of the "Philosophical Transactions," p. 886, The account relates "that he was a poor countryman of Shropshire, whence he was brought up by the Right Honorable Thomas, Earl of Arundel and Surrey, and that he died after he had outlived nine princes, in the tenth year of the tenth of them, at the age of one hundred and fifty-two years and nine months." Other interesting extracts from the letter of Harvey are as follows: "The cartilages of the sternum were not more bony than the others, but flexile and soft." The cause of his death was imputed chiefly to the change of food and air; "forasmuch as coming out of a clear, thin, and free air, he came into the thick air of London, and after a constant, plain, and homely country diet, he was taken into a splendid family where he fed high and drunk plentifully of the best wines." "He was able, even to the hundred and thirtieth year of his age, to do any husbandman's work, even threshing of corn." It is also stated that he married a widow when one hundred and twenty years of age, and from her own statement had frequent sexual intercourse with her. In an essay by Pflüger on macrobiotics, he refers to other recorded cases of unusual longevity. H. Jenkins, a native of Yorkshire, died, in 1670, at the age of one hundred and sixty nine. It is related that on one occasion, when brought before a justice to testify with reference to an event which had occurred one hundred and forty years before, he appeared accompanied by his two sons, aged one hundred and two and one hundred years, respectively. A more remarkable case still is that of Kentigern, or Saint Mungo, founder of the Cathedral of Glasgow, who reached an age of one hundred and eighty-five, if we may trust the accounts of his life on record. Among the exceptional cases recorded some are stated to have been unusually temperate in their habits of life, while others paid no regard to such precautions. In this last category Pflüger mentions one Brawn, who reached an age of one hundred and twenty, although his tombstone records the fact that he was a confirmed drunkard. Outside such evidence as this, it is evident that exceptional longevity cannot be referred solely to careful observance of hygienic conditions. We must explain it, in general terms, as due to an unusual power of assimilation in the living substance composing the tissues, and that this tendency to long life is inherited may be accepted as demonstrated by the statistics of life insurance. At the present day we have numerous cases of persons passing the hundred-year mark by a few years, so that this age cannot be regarded as very unusual. Sir C. Brown, for example, in his interesting paper on old age, states that in 1889 the deaths of seventy-six reputed centenarians were

reported in England and Wales. In his several popular works Metchnikoff has championed the view that the life of man might be prolonged readily to the full extent of its potentiality, until death came in the order of nature, and not as the result of accident or disease. He designates this condition as one of orthobiosis and assumes that when it prevails death is received not as an unwelcomed event but as a natural process to which the mind and body are adjusted. Metchnikoff conceives senility and death as due directly to the phagocytic activity of the wandering cells which prey upon and destroy the nobler elements, such as the nerve cells. The destructive action of these phagocytes is favored by the poisons of disease and especially by the poisons absorbed from the large intestine as a result of the action of the putrefactive bacteria. He has advocated, therefore, certain simple procedures to replace these putrefactive bacteria by less harmful lactic-acid producing bacteria and has assumed that thereby human life will be greatly prolonged. These somewhat naive views have obtained a wide circulation, but it cannot be said that the practice of inoculating lactic-acid producing bacteria into the large intestine has really produced any definite results of the kind imagined by the author.

However, leaving aside the reproductive cells, death sooner or later comes to the rest of the cells of the body, no matter how favorable the environment of life may be. It is not altogether hopeless to inquire into the causes which bring this about, though naturally any such investigation is largely made up of speculations of a very general character. We may define death as a cessation of life. In order, therefore, to arrive at even a general conception of its cause one must first define as clearly as possible what is meant by life. Spencer's definition is perhaps the one most familiar to educated persons. According to him life is the continual adjustment of internal to external relations. When properly analyzed the definition includes a great deal, and it is difficult to criticise it justly. But the physiologist will certainly object to it, because it attempts to present, in the most general terms, only the *ensemble* of properties manifested by living matter without pretending to trace these properties in any causative way to the physical substance that manifests them. It is as though one defined light by enumerating its chemical and physiological effects instead of referring it to vibrations of the ether. For the physiologist an adequate definition of life must be one that connects its phenomena with the structure of living matter. As the chemist may deduce the chief properties of a salt from a knowledge of the structure of its molecule, so the physiologist believes that a scientific explanation of life—that is, of the phenomena of assimilation and reproduction—can be obtained only by discovering the essential structure of living matter. To this end all biological work tends. The adjustment of internal to external relations, and the interaction of the different organs that brings about this adjustment, should be deducible from the chemical structure of living matter in somewhat the same way that the adjustments or reactions of benzene to different external conditions may be foretold from a knowledge of its molecular structure. That this kind of explanation of life is not inconceivably remote is demonstrated by the fact that several chemical theories have been seriously proposed and applied in some detail. Pflüger, for example, suggests that the essential difference between dead and living protein lies in the grouping of the nitrogen in the molecule. In dead protein it may exist in the form of an ammonia compound, while in protein that is living it occurs in part, at least, in the cyanogen grouping. As something approaching scientific evidence for this view he asserts that the oxidation products of dead albuminous bodies—that is, so far as the nitrogen is concerned—are always ammonia compounds, amines, or amido-acids, while the end products of the oxidations of living substances may be classed among the cyanogen bodies. Moreover, the cyanogen compounds are characterized by their instability, and this is likewise one of the most prominent phenomena exhibited by living substances; it is doubtless the chemical cause of what is known as the irritability of living things. Cyanogen compounds also exhibit, in a striking way, a tendency to polymerize, and Pflüger suggests that this property of polymerization may be the essence of what we speak of in general as assimilation or nutrition, by which the living molecule takes into itself the molecule of dead protein. Indeed, says Pflüger, we may look upon the molecule of cyanic acid as showing properties intermediate between those of living and dead matter, as a half-living substance. In a similar way Loew and Bokorney attempt to explain the peculiar properties of living matter on the supposition that its molecule contains an aldehyde group. They find that living protoplasm, in certain plant cells at least, has the property of reducing silver nitrate from alkaline solutions, while dead protein has no such action. They infer that this reducing power is caused by the presence of an aldehyde group, and they give a schema showing that formic aldehyde, by union with ammonia, may produce aspartic aldehyde, and this, by condensation and reduction, with the addition of S, might give a compound of the molecular formula of protein, which as long as it retained the aldehyde grouping would be living protein, and would form the basis of living protoplasm. Latham attempts to combine the theories of Loew and Pflüger by supposing that living protein is composed of a chain of cyan alcohols, united to a benzene nucleus, thus explaining the irritability or instability of living protein, as well as its reducing action. It is now some years since these theories were proposed. It is noteworthy in fact that during the last decade or so physiologists have not been so much concerned with the formulation of ambitious theories to explain the constitution of living matter as with fruitful laboratory investigations designed to throw light on the chemical structure of the food-stuffs and the intermediary stages through which they pass in their metabolism in the body. The structure of the sugars and above all the structure of the proteins are much better known, but perhaps the concrete knowledge thus obtained has had a sobering influence upon the tendency to construct hypotheses in regard to the constitution of living matter. But however inadequate and premature such hypotheses may seem at present, they at least serve to demonstrate the fact that the physiologists and chemists have been looking forward to a definition of life based upon a knowledge of the chemical structure of the substance through which it is made manifest.

Proceeding from his conception of what constitutes life, Spencer defines natural death as a want of correspondence between the internal and external relations. Perfect correspondence would mean eternal existence. If the organism could adapt itself to every change in its environment, old age and death would be impossible. It is difficult to understand the full significance of Spencer's language. Taken literally it seems to assert nothing more than that death is a cessation of life. It adds nothing at all to our knowledge of the causes leading to this cessation, nor does it indicate any fruitful line of investigation. If, however, Spencer means that the fatal want of correspondence may come from without; that is, from changes in environment to which no adequate adaptation can be made by the organism, and in many passages this seems to be implied, then his view is opposed to that accepted by most physiologists. They, the physiologists, believe in general that although the environment were perfect and unchangeable, yet by virtue of inherent changes in the organism itself the assimilative powers would inevitably grow weaker and finally cease with death, or

as the same idea is expressed by Brown. "The causes of death are not to be found in the examination of many external injuries, but are already established within the organism itself, and death is simply the natural end of development." It is within the range of possibilities that the nature of these limitations to assimilation may be discovered by our present methods of investigation. The power of growth wanes from birth and, speaking broadly, disappears on the attainment of the adult condition. For a long period thereafter, in man for sixty years, more or less, the body can still maintain itself by repairing the wastes of the tissues. There is a growth-metabolism therefore and a maintenance metabolism, and something has been done to show that certain food materials may suffice for one and not the other. Thus Osborn and Mendel in their fine experiments upon young rats have shown that certain proteins, *e.g.* glutolin, may serve for maintenance but not for growth, while other proteins may serve for both purposes and still others for neither. Analyses of these proteins in regard to their constituent amino acids or building stones will throw light on what substances are needed in the construction of living matter and perhaps may throw light also on the nature of the specific material needed for growth. Rubner in his thoughtful speculations upon the duration of life states that when this problem is considered from the standpoint of energy each unit of weight of living matter is found to be capable of using a certain definite amount of food material, or expressed in other words is capable of making a certain number of chemical transformations. In the period of adult life (sixty years) each kilogram of man metabolises food material whose available energy equals 725,770 calories. Other mammalia for which data are obtainable have a much more limited power—191,600 calories to each kilogram of animal. This power of assimilation gradually languishes and expires, that is to say old age and death come on from internal causes and these causes operate with such uniformity that the total assimilative work of which the cells are capable may be expressed in a quantitative way. In complex organisms like ourselves this failure of assimilation may come first to some one organ, such as the heart or the nervous system, and through its collapse the organism as a whole ceases to exist. In the nature of the case natural death cannot come to every organ of the body at the same time, so that the death of a portion, perhaps from the standpoint of weight the larger portion of the body, must always be accidental, as, for example, from a shutting off of the blood supply due to natural death of the heart. But this consideration does not affect the general conception of the liability of all the organs to a similar fate. Rightly or wrongly, it is, or has been, a well-nigh universal belief that every organism and every bit of living matter in an organism has only a limited duration of life, no matter how favorable the external conditions may be.

Weissmann, in a series of essays upon the duration of life, has attempted to demonstrate the essential immortality of living matter, or, in other words, to show that death is not an inherent necessity of life, but an acquisition or adaptation on the part of living things. These essays have aroused a widespread interest and discussion among biologists, and are probably the most important speculations of recent times upon the origin and meaning of death. Weissmann carries the problem back to the lowest forms of life, the unicellular organisms or protozoa. Whatever in this regard is true of them must be looked upon as being or as having been true for living things in general, since modern biological doctrines trace the evolution of life from these forms, and modern morphology has demonstrated that all complex forms of life are in fact mere colonies or collections of unicellular organisms. If we study one of the protozoa, the ameba, for instance, which has always been taken as the archetype of life, we find that it is a complete cell; that it feeds, and assimilates, and excretes; that it increases in size, and finally reproduces by simple fission, forming two new individuals, or daughter cells. In this last process we have the disappearance of one old individual and the formation of two new ones, nevertheless there is no death. To speak of the disappearance of the parent cell as an example of death, as some have done, is a mere figurative use of language. There is no death in such a change, because as Weissmann puts it, there is no corpse. If we consider the two daughter cells produced by the fission, we find not only that they are similar morphologically, but that each of them has possibilities of growth and reproduction equal to those shown by the parent form—there is apparently no reason why such a process should not go on indefinitely. Amebæ, as we find them under the microscope, show no signs of old age; the daughter cells are not less capable of reproduction than is the parent cell. It is permissible to suppose that if a single ameba were given a favorable environment it would in time produce an infinite number of descendants, each of them possessing in turn the same unlimited possibilities of multiplication. This is precisely the hypothesis that Weissmann makes when he says that living matter is potentially immortal. It is an alternative hypothesis to the one usually adopted, and Weissmann's contribution to the subject comes not so much from his adoption of this view as from the application he makes of it in considering the higher forms of life in which death is an indisputable reality. Weissmann's theory of the origin of death among the metazoa is developed directly from his hypothesis that living matter was originally incapable of natural death. His direct statement that the simplest unicellular forms of life to-day probably retain this primitive construction of protoplasm has not, however, passed unchallenged. Maupas has made an experimental test of the statement in some very interesting observations. He set himself to observe, throughout an extended period, certain unicellular animals when placed under the most favorable conditions for growth and multiplication. The infusoria were chosen for experiment. After making careful observations upon the best conditions of temperature and food, an individual was selected, placed upon a microscopic slide in a suitable moist chamber, and kept under the most favorable conditions possible for propagation. A faithful record was kept each day of the increase in number, through multiplication by division, of the specimen chosen for study. After the increase had reached some hundreds of individuals, one of them was again isolated and allowed to multiply and so on until unmistakable signs of what he calls a senile degeneration became apparent in the offspring. His experiments lasted for a variable time. In no case were the observations carried over less than fourteen days, and in the case of *Stylonichia pustulata*, upon which the most careful experiments were made, the successive progeny were cultivated for nearly five months.

The rate of growth in some of the species was incredibly fast. Maupas estimates that in six and one-half days a single stylonichia, at a temperature of 25° to 26° C., might produce by repeated fissions a body of protoplasm weighing one kilogram, and in thirty days a mass of protoplasm a million times larger than the sun. He found that after a certain number of generations the progeny began to show signs of a physiological decline. The new animals formed were smaller than normal, seemed weaker, were not so well provided with cilia, and the nuclei contained within them gave microscopical evidence of pathological changes. Maupas looked upon this result as proof of a genuine senility which would have resulted—had the process of isolation been continued sufficiently long—in the natural death of all the descendants, despite the most

favorable conditions for living. After a colony began to show signs of old age he found that if one of the animals was taken out and mixed with another lot having a different ancestry, conjugation took place. The weakened infusorian united sexually with one of the more youthful forms, and rejuvenescence was thereby secured. The descendants of this pair multiplied again with the original vigor and gave rise to normal healthy offspring. In some more recent experiments of the same character reported by Joukowsky results more favorable to Weissmann's views were obtained. Joukowsky used several species of infusoria. His method was to isolate an individual in a moist chamber and feed it carefully. After several days this individual by fission had given rise to a colony of perhaps sixty to one hundred offspring. One of these was then isolated, treated in the same way, and this process was kept up in some cases for many months. His most striking results were obtained with *Pleurotrichia lanceolata*, which he observed during eight months and through 458 generations. During this time no conjugations were seen, and no signs of degeneration or senescence, such as Maupas described, were noticed. Still later work by Woodruff carried out upon the paramecium was continued for a period of five years. During this period the rate of growth was so fast that he estimates that the original individual with which his experiments started might have produced potentially a mass of protoplasm equal to $10^{1000}$ times the volume of the earth. This author believes in line with Weissmann's hypothesis, that under favorable environment a living paramecium may reproduce itself indefinitely.

Let us assume that Weissmann is right in his fundamental hypothesis, and that the first forms of life were potentially immortal, as the simplest forms of life are to-day. What, then, has become of that immortality in organisms like ourselves? What was the origin of death? Weissmann makes the supposition that in the higher animals we have two kinds of living matter, one composing the mass of the body, which unquestionably is subject to a natural death, and one composing the reproductive cells, which is evidently possessed of potential immortality, since if fertilized and kept under proper conditions it will give rise to an infinite number of descendants. The former, the mortal, he speaks of as somatoplasm, the latter, the immortal, as germ plasm. Furthermore, he supposes that the germ plasm, constituting the reproductive cells in any individual, is directly derived from the fertilized ovum from which that individual developed. The fertilized ovum is a single cell; by cell division it multiplies a billion-fold and more to make the body. Of this infinite number of cells those which make up the muscles, skin, etc., although directly derived from the ovum, have become specialized physiologically as well as morphologically to fit them for the performance of their special functions, and at the same time they have lost the potential power of immortality which characterized the germ plasm of the ovum. But among this infinite number of cells there are always certain ones that do not undergo specialization; they remain like the ovum from which they were formed; they retain a portion of the germ plasm with its powers of immortality, and these cells become the ova and spermatozoa from which new organisms may be developed in turn. If we carry back this conception through the line of ancestral forms from which man has been developed, it involves the idea that the germ plasm has been actually continuous throughout the history of living things, and that it represents the immortal protoplasm of the unicellular forms from which the metazoa were evolved. This is the doctrine that goes by the name of the "continuity of the germ plasm," and in the form in which it is presented makes one of the most original contributions given to biology within recent years. The question as we have it before us now may be stated in this way: The unicellular forms are potentially immortal; the many-celled animals contain an immortal germ plasm and a mortal somatoplasm, and yet the many-celled animals have been directly derived from the unicellular forms. In the first many-celled animals produced, the different cells must have had similar properties; they must all have been equivalent to reproductive cells. But subsequently, after specialization of structure and physiological division of labor had become established, it happened that the vast majority of the cells of the body, all those in fact that had undergone differentiation in structure and function, lost the power of perfect nutrition, and became subject to old age and death. Upon what biological grounds can we explain this variation? Weissmann refers it to the operation of the law of natural selection, and states his theory briefly in saying that death is an adaptation, acquired because of its utility to the race on the one hand, and, on the other hand, because, after the beginning of a differentiation in function among the cells, the possession of immortality by all the cells was no longer of any value to the race, and therefore was not brought under the preserving influence of natural selection.

With reference to the first of these reasons, the utility of death to the race, it must be borne in mind that if natural death had not appeared, and creatures could have been destroyed only by fatally adverse changes in their environment, then we may imagine that every species would have been burdened in its fight for existence by individuals whose physical value had been impaired by previous minor accidents, such as loss of limbs, etc. There would have been, from the pitiless standpoint of natural selection, many useless mouths to feed. Weissmann was inclined in his first essays to lay great stress upon this point, but in later years he emphasized chiefly the second of the reasons given above, namely, that immortality was lost to the non-reproductive cell because, being of no direct value in the perpetuation of the species, it was not acted upon and preserved by natural selection. The tendency of structures to retrograde and disappear when their value to the species becomes *nil*, even though they may not be actively injurious or burdensome, because natural selection no longer acts to preserve them, is something of a new idea in biology. Weissmann attaches great importance to it, and has coined for it the term panmixia. A simple example of its action is seen in the absence of eyes in the cave-inhabiting animals. Many of the crustacea living in the dark caves have lost their eyes—by panmixia, Weissmann would say; that is, in their peculiar environment their eyes are no longer of use, and they have therefore degenerated and disappeared, in the course of generations, by the lack of the direct preservative influence of natural selection. So Weissmann thinks that the original immortality of living matter became lost to the non-reproductive cells in the many-celled animals because, being of no value to the species, indeed, on the contrary, threatening the species with an unnecessary burden, natural selection let it alone. To the writer's mind this kind of argument, indeed, the whole idea of panmixia, seems to be very incomplete, it lacks all suggestions of a specific cause. In physiology we are familiar with many examples of retrogression of structure following upon disuse. A muscle or gland thrown out of function by severance from its motor nerve, or a nerve cell cut off from its normal connections, atrophies from disuse. But the explanation given is specific to the extent that it refers the atrophy to an altered metabolism. Functional activity in specialized tissues seems to be necessary for their normal metabolism, and lack of activity, as in the paralyzed muscle, is followed by a perverted metabolism that results in the destruction of the tissue. In the same way the loss of perfect nutrition in the somatoplasm might readily be referred, as in Weissmann's first explanation, to an altered metabo-

lism that, arising spontaneously, was subsequently preserved by natural selection, because it proved advantageous to the species.

Many eminent biologists have found a logical difficulty in understanding how from cells originally immortal cells that were mortal could have been derived by differentiation of any kind. They hold that natural selection can operate only upon a structure that exists, it cannot create a thing outright. If living matter was all originally immortal, how could natural selection, by negative or positive action, produce mortality, if in some degree this latter property were not already inherent in living matter. As one of the objectors (St. George Mivart) puts it, the difficulty is to understand the first step, the beginning of something from nothing. Objections of this kind are of course fallacious; it is curious that they should have been made seriously by eminent men. The words mortality and immortality do not stand for definite things; they are not substances or entities, or whatever term of this kind one may choose to use. On the contrary, they are in this case merely convenient phrases to express the kind of nutrition going on in living things, whether it is self-perpetuating or self-limiting. They are properties that are connected with the physical or chemical structure of living matter, and this latter is a thing that does exist and may be acted upon and modified by natural selection in many ways.

In accepting or refusing Weissmann's theory of the origin of death, everything seems to depend upon the validity of his fundamental hypothesis with regard to the absence of natural death among the primitive forms of life. If we admit that there are simple organisms, such as the bacteria or the amebæ, that do not propagate by conjugation or by any method of multiplication other than simple fission, it would seem logically impossible for such a species to be perpetuated unless its protoplasm is exempt from senility. If we do not accept this solution, then we must suppose either that there is some kind of sexual rejuvenation that has not yet been discovered in these particular forms, or that there is some process of molecular rejuvenation occurring at periods in the life history of such forms that brings the living substance back to its primitive constitution and nutritive vigor. Götte has clearly recognized this necessity, and has proposed a theory that is logically acceptable. According to Götte, death is a necessity immanent in life. As regards the unicellular forms of life, he avoids the difficulty that has just been described by assuming that the process of encystment is the death of the old individual and the beginning of a new one. Encystment, of course, is known to occur among the unicellular forms. During the process the visible evidences of life, such as movement, come to an end, to be renewed again after a certain period or under more favorable conditions. Götte believes that during the encystment a change of molecular structure takes place. There is first a dissociation or dissolution, which is an actual death, inasmuch as the properties of living matter are lost. This, however, is succeeded by a stage of reconstruction with the formation of new protoplasm possessed of the primitive powers of assimilation, and capable of developing and multiplying for a certain period. This is obviously an hypothesis that it is practically impossible to test by chemical investigations. To the physiologist it will probably not be acceptable on theoretical grounds because of the difficulty of conceiving how matter once in the dead form can again pass into the living form, as the result of spontaneous molecular activities, and without the aid of an exciting or liberating force. Dead matter, as we know it, is converted into the living form only by the process of assimilation on the part of matter already living, whereas the hypothesis of Götte calls upon us to believe that the transition may take place by virtue of the intermolecular movements in the dead matter itself. Encystment, then, according to the theory of Götte, represents at the same time the primitive form of natural death and the primitive method of reproduction. As the metazoa have been derived from the unicellular forms, he further assumes that among the former both natural death and reproduction have been acquired by direct inheritance. As in the protozoa reproduction and death stand in a causal relationship, so in the simpler forms of metazoa, *e.g.* in the orthonectidæ, this connection is still maintained, inasmuch as the liberation of the ova results in the death of the individual. Among the higher forms the relationship between reproduction and death is not so evident, though the theory demands always a causal connection between the two processes.

It will be evident from this brief statement of Götte's views that he differs from Weissmann, not only in his belief of the necessity and universality of death, but also in respect of the discontinuity of life. Among the protozoa that propagate by encystment, his theory denies that the new individual is directly sprung from the living substance of the parent cell. On the other hand, the general belief has been that in some way the continuity of life is maintained. Darwin's theory of pangenesis, which was formulated to explain the phenomena of heredity, implies a continuity of living matter between parent and child. It will be remembered that in this theory the ova and spermatozoa are supposed to contain minute germs, gemmules, thrown off from the different cells of the body and collected in the germ cells. Under the proper physiological stimulation, the gemmules develop into organs like those from which they were derived. The gemmules must be regarded as living matter; hence the theory implies a direct carrying over of living substance from parent to child, a continuity of living matter at least. In contrast with this the theory of Weissmann supposes a direct continuity of germ plasm, the essential part of the germ cells of the child being an actual portion of the germ protoplasm of the reproductive cells of the parents. The immortality of the germ plasm and the direct continuity of the germ plasm are, then, the fundamental parts of Weissmann's theory, and his hypothesis of the origin of death as regards the somatoplasm follows naturally if we accept these premises. It will be observed, however, that Darwin's pangenesis theory may also be regarded as implying the essential immortality of the material composing the germ cells, although neither Darwin himself nor those who have made use of his theory have ever made a specific statement of this kind.

In the older treatises upon the nature of death a distinction was often made between molecular death and somatic death. The former term was meant to include those changes of disassimilation or catabolism, to use a more modern word, which are supposed to be in play in every bit of living matter, and to lead to the formation of dead waste material, such as urea, carbon dioxide, and water. Somatic death was used, as it is at the present time, to describe the final cessation of all vital activities in the body at large. It was supposed that we had here the production of dead from living matter by two entirely different methods. The term molecular death is obviously an unhappy one, and has fallen into disuse, although it is possible that it is an accurate statement of what takes place. The essential nature of the physiological oxidations which lead to the formation of the products of disassimilation is at present a subject of discussion, and will probably remain so for a long time. Treating the subject in the most general way, it seems evident that in disassimilation one of two things may take place. If, for the sake of simplicity, we confine our attention to a single cell, then it is possible, on the one hand, that the formation of the wastes of nutrition is brought about by the actual death and disintegration of por-

tions of the cytoplasm, their places being supplied by new living material formed in other parts of the cytoplasm or in the nucleoplasm. Or, on the other hand, it is equally possible that in normal disassimilation no single living molecule undergoes total destruction. The process of dissociation may be such that only a portion of the molecule is split off, and lost from the cell as dead material, while the remainder of the molecule reconstructs itself from the food material of the cell juices into the originally complex molecule of living matter. This, in fact, is the hypothesis of physiological oxidation which has been proposed by Pflüger with special reference to the metabolisms of muscle during functional activity and similar views have been suggested to explain the nature of the metabolism of maintenance in the body as opposed to the metabolism of growth in which new living material is constructed wholly anew. From this point of view molecular death in the old sense might be supposed not to exist.

W. H. Howell.

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**Death, Signs of.**—The one infallible proof of death is putrefaction, as manifested first by a peculiar greenish discoloration of the skin of the groins and contiguous portions of the surface of the abdomen. This discoloration is accompanied by the odor of putrefaction. It is generally stated that the greenish color appears in from twenty-four to thirty-six hours after the death struggle. Certain conditions, as hot weather and exposure to the air, accelerate, while cold and protection from the air retard. Under various combinations of circumstances we may note the discoloration as early as fifteen hours and as late as four or five days after death. As a rule these extremes present nothing paradoxical, since they are readily explained by environment. The original discoloration tends to extend regularly over the skin until the whole of the latter is involved, the rate of speed varying with the conditions originally present. Thus early putrefaction implies rapid diffusion, and *vice versa*. Before diffusion is complete new isolated putrefactive foci may appear at remote areas—the neck for example. As a rule in from eight to ten days putrefaction is complete, and the color has changed gradually from greenish- to reddish-brown.

For many reasons which need not be detailed here, it is of great advantage to be able to demonstrate the existence of death long before the stage of putrefaction is in evidence. For centuries we have depended on the coexistence of numerous empirical data—the general cadaveric appearance, rigor mortis, algidity, etc. These together with complete cessation of all vital functions as estimated by refined tests are still considered as more than sufficient evidences of death, especially when the causes and antecedent phenomena are jointly in evidence. It is not too much to say, perhaps, that such evidence almost always satisfies the practitioner. But the laity have an all-prevailing fear of burial alive, and moreover in communities where no physician is available, laymen dread to pronounce one of their number dead. There are occasionally seen border-line cases between life and death, with a remote possibility of reanimation, which have rendered the most experienced physicians cautious in pronouncing one dead who shows only certain of the phenomena of death, such for example as the cadaveric appearance, coldness of the surface and apparent failure of the heart and lungs.

We therefore owe much to Icard, the renowned medical jurist of Marseilles. Apparently with an almost sole view of enlightening the laity, he has perfected two scientific and infallible tests based on putrefaction and the complete irrecoverable failure of circulation which makes possible the latter. His book "Le signe de la morte réelle en absence du médcine" (Paris, 1907) shows by its title that it is written for the instruction of the public. It is devoted almost entirely to his two tests, known respectively as the "fluorescein" and "sulphydric," to be described later. The former cannot indeed be carried out by the laity and is hence spoken of by Icard and his colleagues as the "medical sign." The sulphydrate sign is intended for the laity.

Icard produces documents which show that algidity, rigor mortis, and even the green discoloration and cadaveric odor have deceived the laity, and that carelessness on the part of ordinary medical practitioners has sometimes caused these signs to be overlooked or wrongly interpreted.

The now well known fluorescein test was first introduced by Icard about a decade ago and is based on the ready absorption by the stagnant blood of the most sensitive of staining substances—fluorescein. Thus if, after death has apparently occurred, the injection of fluorescein causes a bright yellow discoloration of the skin, suggesting jaundice, with a brilliant emerald green hue of the eyes, the patient is surely dead. The negative phase of the reaction is of less consequence for it indicates simply that the patient still has life in him, that the circulation is not yet abolished. There may or may not remain some hope of reanimation. The injected drug is said to be perfectly harmless, if there is still life, though it is believed by some authorities that heart massage should follow the injection of fluorescin.

The sole possible criticism of the fluorescein test is that it does not always supervene promptly, in which case it loses much of its value. Icard, who does not have this experience, makes use of a standard solution, viz., fluorescein ten grams, sodium carbonate

fifteen grams, and distilled water 50 c.c. This he would inject in a number of localities simultaneously, into both the muscles and veins.

Another test introduced by Icard is based upon the theory that putrefactive changes should occur in the viscera before they appear in the skin, and that it should become possible to recognize them. Should such changes occur in or near the lower respiratory tract and lungs, the most volatile of the liberated gases should escape by the nostrils, naturally in extremely minute quantities. The most volatile gases formed in animal decomposition are hydrogen sulphide and ammonium sulphydrate. To prove the presence of these gases, white test papers soaked in fifty per cent. sugar of lead solution and then dried are rolled up, moistened, and inserted into the nostrils. Very slowly the papers assume a brown color from the formation of lead sulphide. This reaction, while slow in appearing, always precedes the discoloration of the skin by a clear margin. Should any lesion like a decomposing cancer be seated about the respiratory organs, this test would of course be vitiated.

It having been conceded that putrefaction is the sole infallible spontaneous sign of death, it follows that all other criteria must be of the nature of *induced tests* (based upon putrefaction), which may be used universally in a routine manner as soon as death occurs. But despite the great labors of Icard and the adoption of his methods by his countrymen we must admit that they have not been even tested in many localities where the time-honored textbook signs of death are still found sufficient. In recent years the most extensive monographs on death have chosen to consider the subject in types depending on the cause. In other words they are essentially forensic in character, and seem to be written chiefly from the viewpoint of the coroner and his inquest.

Naturally in an academic study of the signs of death, irrespective of the cause, we do not look to find many new data. The phenomena of death have come down to us largely unaltered from the great medical jurists of the past century. A very good résumé of the signs as a whole is the subject of an article by Stockis of Liège (*Revue de Médecine Légale*, March, 1909). He enumerates *functional arrest of the nervous system* which causes the cadaveric attitude and expression. Many induced tests have been devised to demonstrate loss of innervation which need not be detailed.

*Eye signs*, the sunken eye; parted lids; failure of pupil to respond to alkaloids; ophthalmic examination of fundus (where arrested circulation may be apparent —also early putrefactive changes in the media); the dionin or ether test which is said to redden the conjunctiva if life remains.

In regard to determining *cessation of the circulation*, we have a number of instruments of precision to draw upon, also tests for peripheral arrest like transillumination of the fingers. These have all been superseded wholly by Icard's fluorescein test.

*Rigor mortis* is an important sequel of death which comes and goes and is sometimes absent, and in general shows great vagaries. It may be mimicked by antemortem conditions. Trustworthy as it may seem it has no connection with abolition of circulation and putrefaction, to which alone our efforts should be directed as being constant, inevitable phenomena. What is true of rigor mortis applies equally to *algidity*.

A new alleged sign, *radiography of the abdomen*, which is claimed to render visible the phosphorescence in the decomposing intestines, has been pronounced of no value. Stockis regards Icard's two tests as in a class above all others, with the possible exception of ether dropped in the conjunctiva of one eye, as already mentioned. A response in the form of rubefaction shows that circulation is not yet abolished. In the instance of apparent choloroform death this test might be the means of eventual reanimation. This ether test was introduced by d'Halluin, who also added cardiac massage to the fluorescein test.

EDWARD PREBLE.

**Dechloridation.**—Dechloridation is a term commonly used to indicate the reduction of sodium chloride in the tissues and fluids of the body by abstention from the use of salt in the diet. The so-called "salt-free" diet is free from salt only in that none is added artificially to the food, which therefore contains only the amount of sodium chloride with which it was endowed by nature. Man normally requires about one or two grams of sodium chloride, when living upon a mixed diet; as a rule, the amount of sodium chloride ingested is ten times this amount. So that it is the rule, apparently, that man ingests much more than he requires.

The ingestion of sodium chloride stimulates the flow of saliva, and assists in the conversion of pepsinogen into pepsin. Therefore, limiting the ingestion of salt will tend to lessen these processes. Thus dechloridation, with the limitation of condiments in general, is of value in hyperchlorhydria.

It is especially in the anasarca of parenchymatous nephritis that dechloridation has been found of value. As is true in so many instances in the history of medicine, this discovery was apparently made independently by several observers. In this country important articles appeared in 1905, by A. O. J. Kelly and Charles A. Fife of Philadelphia and Joseph L. Miller, of Chicago. The statements as to the value of dechloridation in parenchymatous nephritis did not pass unchallenged. Thus Ferrannini[1] in the same year, 1905, held that there was no foundation for the view that dechloridation is of value in parenchymatous nephritis, declaring that salt is often beneficial in "kidney diseases," and that a "salt-free" diet is often followed by a temporary increase in the albumin and kidney elements in the urine.

Rumpf,[2] in the examination of material from all sorts of nephritis, found that (*a*) in adults in many cases the salt content of the kidneys exceeded that of the blood and other organs; (*b*) in many cases the salt content of the blood and tissues was increased in amount beyond the normal; (*c*) the pericardial, pleural, and peritoneal fluids showed no uniformity in their salt content, and (*d*) the peritoneal fluid in cases other than nephritis often showed a high salt content.

Widal[3] advocated a salt-free diet in parenchymatous nephritis. He considers the object of the treatment to be two-fold: to free the system as much as possible from salt and therefore from water; and when this has been accomplished, to bring about a balance between the salt in the body and the permeability of the kidneys for salt. The observation of Widal and Javal, that many nephritics are unable to eliminate sodium chloride in the normal manner, has found confirmation and explanation through the work with the colloids.

Boyd[4] noted that a patient with general anasarca had a marked dislike for foods containing salt, and when he followed his inclination and avoided such foods, there was a marked diminution in the anasarca. After observing this case and studying the literature, Boyd tried the effect of salt-free diet in nephritis. In one case, a patient who had been edematous for years, lost the edema in seventeen days.

The inclination of the patient is not a safe guide in dietetics. Bryant[5] noted a case in a physician forty years of age, who showed persistent edema that was apparently due to the habit of eating salt inordinately.

Sodium chloride, whether administered with the food, or subcutaneously or by enema, may induce or aggravate edema in parenchymatous nephritis. The albumin in the urine seems to be influenced by the ingestion of salt rather than by the amount of albumin in the food.

Dechloridation has little or no effect upon anasarca due to cardiac failure.

The diet list advocated by Widal, includes bread made without salt, meats and fresh fish cooked without salt, eggs, butter, potatoes, rice, raw fruits, peas, carrots, stringbeans, watercress, artichokes, salads made with oil and small amounts of pepper and vinegar, jelly, honey, tea, coffee, chocolate, lemonade, syrup, cider, and pastry made without salt. It should be remembered that sweets and the injudicious use of condiments may derange digestion to the detriment of the patient.

Peabody[6] found the following diet satisfactory:

Breakfast: Coffee or tea, eggs, cereals, cream, fresh butter, fruits, and bread made without salt.

10.00 A. M.: A glass of milk.

Dinner: Chicken, fish, potato variously prepared, bread made without salt, ice-cream, jelly, fresh butter, and one cup of cocoa.

3.00 P. M.: A glass of milk or water.

Supper: Eggs, chicken, bread made without salt, jelly, custard, cream, fresh butter, and one cup of tea.

8.00 P. M.: A glass of milk or water.

The unsalted bread is palatable and does not become hard and dry so quickly when made with milk instead of water. Almost any kind of meat or vegetable can be given, to which salt has not been artificially added.

Dechloridation in diabetes is discussed by Dr. A. Rodriguez[7] of Caracas. In the examination of the urine of diabetics, Rodriguez became convinced that there is almost always a hyperchloridation of the urine in these cases. In diabetics the chloronitrogenous coefficient (the relation between the chlorine of the chlorides and the total nitrogen) is greater than normal, and there is a close relation between this coefficient and the excretion of sugar. He observed that the ingestion of sodium chloride induces the retention of the salt and the elimination of sugar, and the same phenomena occurred after the injection of a one per cent. solution of sodium chloride. It is possible that milk, meats, and potatoes are useful in diabetes because they assist in the dechloridation of the organism. Dechloridation has been tried by Rodriguez in diabetes and he has found that in every case the sugar decreased progressively, except sometimes during the first few days.

Dechloridation is advantageous when administering the salts of the other halogens, especially the iodides and bromides. Most attention has been directed toward the limitation of the sodium chloride in the diet when giving the bromides, particularly in epilepsy. When done for this purpose, dechloridation may be agreeably accomplished by substituting the bromide salt, preferable sodium bromide, for the sodium chloride in the salt container.

GEORGE E. MALSBARY.

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**Decidua.**—From the fact that the uterine mucous membrane is cast off at the end of labor this tissue is called the decidua. Since Moericke, Gebhard, Findley, and others have demonstrated that very little, if any, of the endometrium is lost at the time of menstruation the expression "menstrual decidua" has been dropped. And according to present usage the term "decidua" always refers to the mucous membrane of the uterus as transformed through the influence of pregnancy.

As to when the alterations begin which give rise to the decidua there may still be room for a difference of opinion, but the studies of Hitschmann and Adler indicate that the initial changes occur even before the ovum is fertilized. These investigators have shown that in healthy women during the child-bearing period the endometrium is never completely at rest. The rhythmical changes which constitute the menstrual cycle include the following phases: (1) The *Interval*, fourteen days. (2) The *Premenstrual*, six days. (3) The *Menstrual*, three to five days. (4) The *Postmenstrual*, four to six days.

The condition of the uterine mucous membrane usually described as normal is that prevailing during "the interval." As the end of this phase approaches the stroma cells enlarge and are less closely packed together; the glands also become more active. During the next six or seven days these features are accentuated, and, as a result, the thickness of the endometrium is increased two or three times. In this premenstrual hypertrophy the underlying factors are, (1) congestion of the capillaries; (2) edema of the stroma; and (3) swelling of the glandular epithelium. Whenever conception does not take place there follow retrogressive changes which constitute the menstrual and postmenstrual phases. On the other hand if, meanwhile, a fertilized ovum reaches the uterus, elaborate arrangements are made for its protection and nutrition. These provisions are expressed in the formation of the decidua.

The premenstrual condition of the endometrium (Fig. 1639) strongly suggests that it is an early stage of decidual formation, and may, indeed, be regarded as a preparation for the reception of the ovum. It is

FIG. 1639.—The Endometrium During the Premenstrual Phase. (Hitschmann and Adler.)

almost certain, however, that implantation can take place at other times during the menstrual cycle. Accordingly, Bryce and Teacher hold that the object of menstruation is merely to maintain the endometrium ready for the formation of decidua. If this view be correct, the resemblance between the premenstrual condition of the endometrium and the decidua is purely accidental.

A notable degree of development of the decidua has been present in even the earliest ova that have been described, and, therefore, it must be true that almost immediately after the fertilization of the ovum the process of decidual formation becomes firmly established. Under the influence of pregnancy, whether occurring in the uterus or in the tube, the smooth, velvety endometrium becomes thicker and its surface marked by numerous irregular furrows which give it a mammillated appearance. Under the magnifying glass numerous small openings can be distinguished, which represent the mouths of the uterine glands.

The decidual formation is limited to the body of the uterus and does not extend below the internal os; though in rare instances, as stated by Franqué, Von Weiss, and Lynch, isolated decidual cells may be found beneath the epithelium of the cervical canal.

It is customary to describe the decidua as consisting of three portions: the general lining of the cavity of the uterus—the decidua vera; the portion immediately beneath the ovum—decidua serotina or basalis, and the portion surrounding the ovum and shutting it off from the rest of the uterine cavity—the decidua reflexa or capsularis (Fig. 1640). The terms reflexa and serotina date from the time of William Hunter. In the explanatory text to his Atlas, which was edited by his brother John and Matthew Baillie, it was stated that the decidua represented a fibrinous exudate from the lining membrane of the uterus, which formed a complete cast of its cavity and completely covered

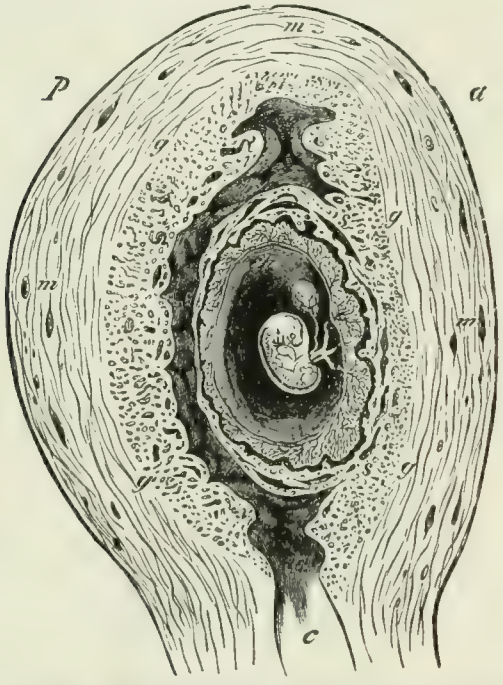


Fig. 1640.—Semi-Diagrammatic Outline of an Antero-Posterior Section of the Gravid Uterus and Ovum of Five Weeks. (After Allen Thomson.) *a*, Anterior surface; *p*, posterior surface; *m*, muscularis; *g*, inner margin of metamorphosed mucosa; *s* to *s*, area of *decidua serotina;* all the parts of the mucosa adherent to the uterine walls not in the area of the serotina constitute the *decidua vera; ch*, chorion, within which is the embryo enclosed in the amnion, and attached to the walls of the chorion; appended to the embryo is the long-stalked yolk sac; the chorion is covered in by the arching extension of the mucosa, which is the *decidua reflexa, r, r.*

the tubal openings. Accordingly, when the fertilized ovum reached the uterine end of the tube, it found its passage opposed by the decidua vera, which it was obliged to invaginate before it in order to gain access to the uterine cavity, whence the term "reflexa." By the pushing forward of this structure, the portion of uterus behind it became denuded of decidua, and a new membrane was developed at that point, which was designated as the new or serotinal decidua, to which the ovum became attached.

This conception of the decidua was maintained until 1840, when Weber and Sharkey demonstrated that it contained structures which they identified as uterine glands. Thus it became necessary to explain the formation of the decidua reflexa in a different manner; and it was suggested that the ovum, upon reaching the uterus, found the entire cavity lined by decidua vera, to which it became attached at a point somewhere in the neighborhood of the fundus. Immediately afterward the vera began to proliferate and form

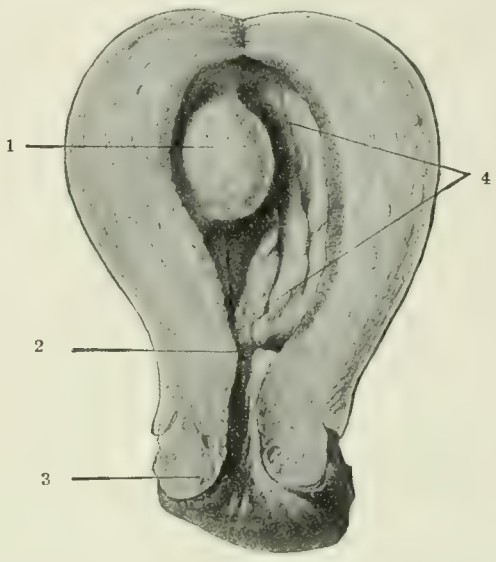


Fig. 1641.—The Uterine Cavity at About the Fourth Week of Pregnancy. Size. (Bumm.) 1, The ovum covered by the decidua reflexa (capsularis); 2, internal os; 3, external os; 4, decidua vera.

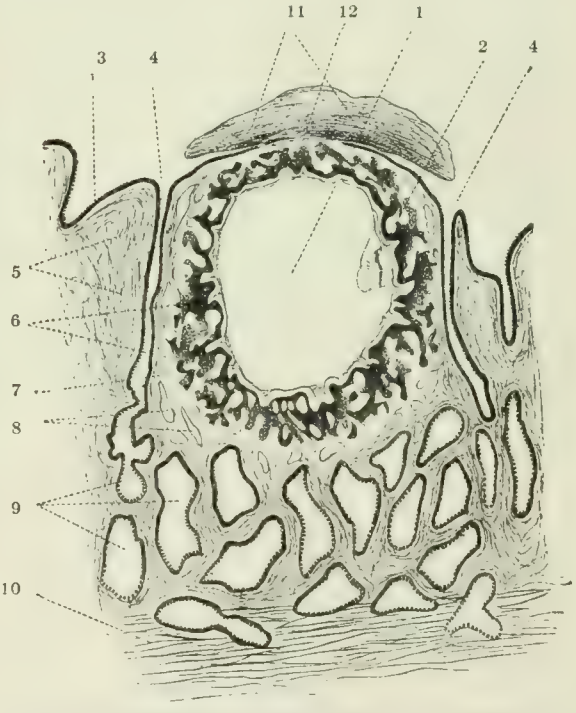


Fig. 1642.—Diagram of a Very Young Ovum Described by Peters.–(Size 1.7 by 0.9 mm.) 1, Cavity within the ovum; 2, embryonic area; 3, surface epithelium of the endometrium; 4, mouth covering the ovum; 7, embryonic mesoderm; 8, capillaries; 9, glands; 10, muscle-fibers; 11, blood-clot covering 12, the point where the ovum entered the endometrium.

a wall around the ovum, which gradually increased in height until it completely encapsulated it. In 1899 the description of a young ovum by Peters (see article on *Chorion*) revolutionized our ideas of the mechanism

of implantation. This specimen indicated that the process in Man was quite similar to, if not identical with, that previously described by Von Spee in the guinea-pig. According to this view the human ovum becomes adherent to the surface of the uterine mucous membrane, burrows its way beneath the epithelium, and comes to rest in the stroma of the endometrium (Figs. 1642 and 1643). In all probability the active agent in the imbedding of the ovum is its trophoblastic covering which, as Grafenberg has shown, contains a proteolytic ferment. Contrary to what was at first supposed, the amount of maternal tissue destroyed by the act of implantation is not very great. In the guinea-pig, for example, Von Spee states that only six or seven cells in the surface epithelium are lost.

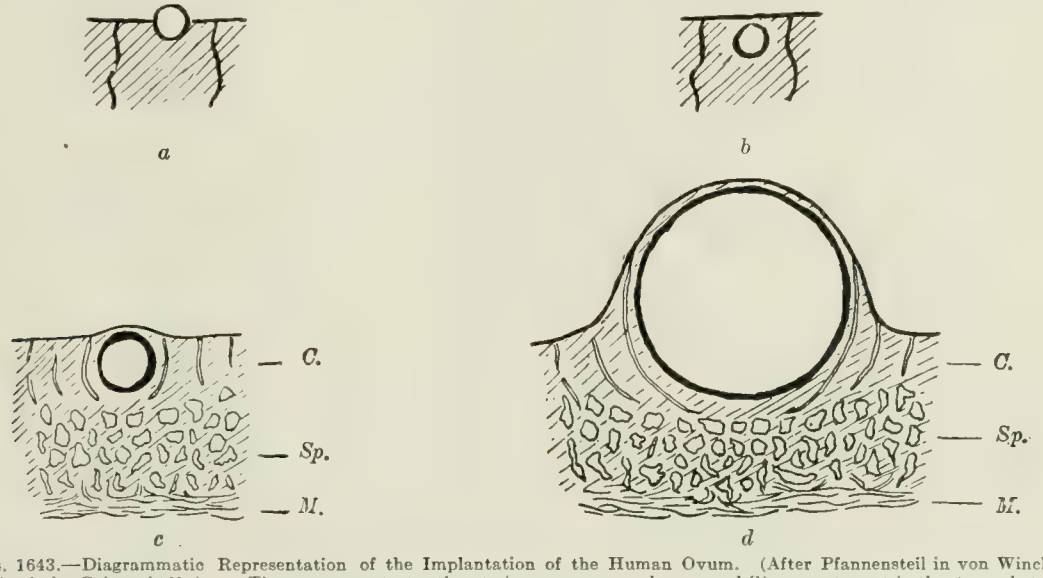


Fig. 1643.—Diagrammatic Representation of the Implantation of the Human Ovum. (After Pfannensteil in von Winckel's Handbuch der Geburtshülfe.) *a*, The ovum penetrates the uterine mucous membrane, and (*b*) comes to rest in the stroma between two glands; *c*, the growth of the ovum elevates that part of the endometrium which lies above it, and (*d*) leads to the development of the decidua reflexa (capsularis). *C*, compact layer of the decidua; *Sp*, spongy layer; *M*, muscle fibers.

The ovum comes to rest in the upper part of the stroma, and the aperture at the surface of the mucosa is quickly closed by a blood-clot which could be demonstrated in the specimen of Peters. Later, the coagulum is absorbed and the lining of the uterine cavity is restored.

As the ovum grows it pushes toward the uterine cavity that part of the mucous membrane which lies above it; and thus is formed the structure to which Hunter gave the name decidua reflexa. A more appropriate designation—now that we understand its mode of formation—is decidua capsularis (His). The part of the mucous membrane directly beneath the ovum, decidua serotina (Hunter) is best called the decidua basalis (His). That the name of the decidua vera be changed to decidua parietalis has recently been suggested by Bonnet.

Decidua Vera or Parietalis.—This is merely the hypertrophied mucous membrane of the uterus outside of the site of implantation, and contains the same histological elements as the normal endometrium, yet in a form strikingly modified. Friedlander first called attention to the fact that the decidua vera is composed of two zones; a compact layer adjoins the uterine cavity, and a loose, spongy layer, composed chiefly of dilated glands adjoins the uterine musculature. The compact layer is composed of large, oval cells with lightly staining, vesicular nuclei. They are called *decidual cells* and at one time were thought to be characteristic of pregnancy; but at present it is generally recognized that a similar development of the stroma occurs in the premenstrual endometrium, especially in cases of membranous dysmenorrhea.

The decidua vera rapidly increases in thickness during the early months of pregnancy, and by the end of the fourth month has attained a thickness of eight to ten millimeters. After this period, owing to the marked increase in the size of the uterus, it gradually becomes thinner so that at the end of pregnancy it is rarely more than two millimeters thick. Under the microscope the compact layer is seen to be made up of large, round, oval, or polygonal cells, distinctly epithelioid in appearance, which possess round, vesicular nuclei staining faintly with hemotoxylin. When the tissue has been spread apart by hemorrhage or edema, or in teased specimens, it is seen that many of the cells which present a stellate appearance are supplied with long protoplasmic processes which anastomose with similar processes from neighboring cells. In the early months of pregnancy the compact layer is traversed by the ducts of the uterine glands, which, however, gradually disappear, all trace of them being lost after the third or fourth month.

The spongy layer is formed by the distended and hyperplastic glands of the endometrium, which are separated from one another by a minimal amount of stroma. In a good many instances the glandular hyperplasia is so marked and the glands assume such irregular shapes that this layer suggests an adenoma in appearance. In certain of the lower animals—notably the Ruminants—the glandular secretion serves to nourish the embryo, and on this account has been called "uterine milk" or "embryotrophe" (Bonnet). So far as known, however, the secretion has no such function in the human pregnancy.

In the early months, the glands of the spongy layer are lined by a single layer of characteristic cylindrical epithelium. This gradually becomes more cuboidal in shape and undergoes fatty degeneration; in great part it is cast off into the lumina of the glands, though a small part of it remains intact throughout pregnancy. From these remnants the endometrium is regenerated after labor. In many instances the formation of decidual cells is almost entirely limited to the compact layer, while the stroma between the dilated glands closely resembles that of the non-pregnant uterus.

Klein directed attention to the fact that the epithe-

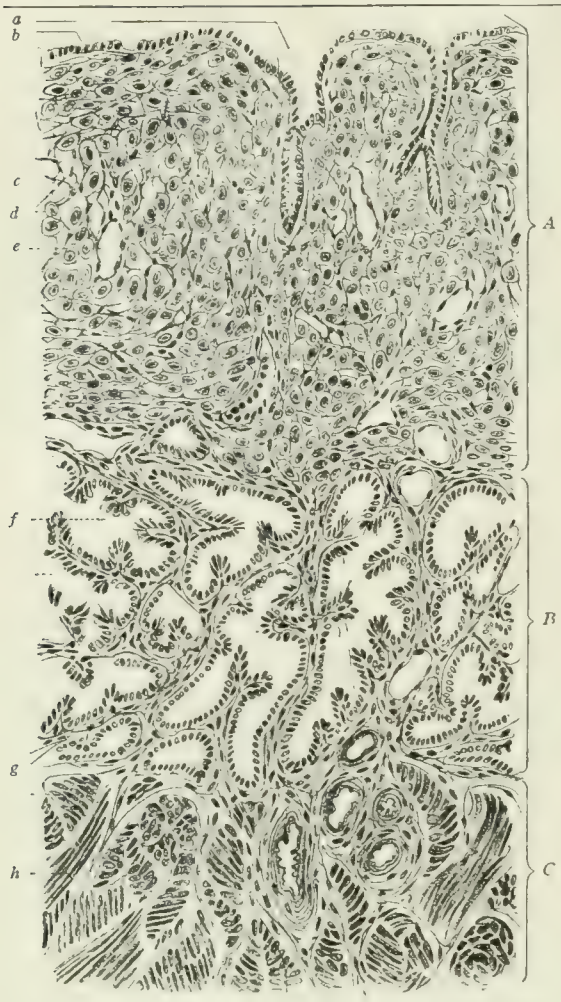


Fig. 1644.—Decidua Vera about the End of the Third Month of Pregnancy. (Bumm.) *A*, Compact layer; *B*, spongy layer; *C*, uterine muscle; *a*, mouth of gland; *b*, surface epithelium; *c*, reticular network; *d*, decidual cells; *e*, capillary; *f*, dilated glands; *g*, muscle fibers in cross-section; *h*, muscle-fibers cut lengthwise.

lial cells covering the surface of the decidua gradually lose their cylindrical shape and become cuboidal and even flattened, and sometimes resemble endothelial cells.

As a result of the work of Hegar, Maier, Leopold, Minot, and many other observers, it is now generally admitted that the decidual cells are derived from the stroma cells of the endometrium, and are therefore of connective-tissue origin. The change consists of an hypertrophy of the pre-existing cells, rather than an actual increase in their number. Their connective-tissue origin was still further confirmed by finding that decidual cells are formed in the stroma of the folds of the tube in tubal pregnancy, and in the subperitoneal connective tissue in normal pregnancy. Furthermore Schmorl, Kinoshita, and others have shown in women dying just after child-birth that the peritoneum covering the posterior surface of the uterus, Douglas' culde-sac, and the anterior surface of the rectum, is frequently studded by small nodules, some of which are just visible to the naked eye, while others are one or two millimeters in diameter, which are composed of cells which do not differ from the decidual cells in appearance, and are undoubtedly derived from the subperitoneal connective tissue.

Before their true nature was definitely demonstrated, various theories were advanced as to the origin of the decidual cells. Hennig and Langhans believed that they were derived from leucocytes, Frommel and Overlach, from the uterine epithelium, and Ercolani, from the endothelium of the blood-vessels; but at present these views are of interest only from an historical standpoint.

Decidua Capsularis or Reflexa.—Except for the first few hours after its entry into the uterus, the ovum is shut off from the rest of the uterine cavity by the decidua reflexa, which forms a distinct capsule around it. In the early months of pregnancy, this structure does not completely fill the uterine cavity so that a space of varying size exists between the vera and the capsularis. But after the fourth month the capsularis, distended by the growing ovum, comes in contact with the vera, so that the uterine cavity is completely obliterated. In a short time the two structures fuse together, after which the capsularis gradually degenerates and disappears. This view was first advocated by Minot, and appears to be well founded, for sections through the wall of the full-term uterus outside of the placental site show that the

Fig. 1645.—Section through Compact Layer of Decidua. ×420. (From William's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

entire decidua is only two to three millimeters thick, and in it no trace of the reflexa can be discovered (Fig. 1646).

The capsularis usually attains its greatest thickness at about the second month, when it is two to three millimeters thick. Sections through it at this time show that it is made up of typical decidual cells, and is covered on its exterior by a single layer of flattened or cuboidal epithelium; while its interior is in contact with the villi of the chorion leve, and at no time shows any trace of epithelium. In its lowest portion, where it is connected with the vera, an occasional gland may be found, and when their ducts are present they are seen to be open only upon the exterior of the membrane.

the two varieties of cells, but after more careful study, particularly when groups of cells are examined, their characteristic differences can be readily appreciated. Usually a layer of canalized fibrin occupies a part of the decidua basalis, and, as a rule, forms the boundary line between fetal and maternal tissue; the tissue internal to it being composed almost entirely of fetal ectoderm, with a slight admixture of decidual cells; while the tissue external to it is made up almost entirely of decidual cells with only isolated areas of fetal tissue. After the middle of pregnancy numerous giant cells may be distinguished in the deeper layers of the serotina. They are simply portions of syncytium which have wandered down into the deeper layers of the decidua and are, therefore, of fetal origin.

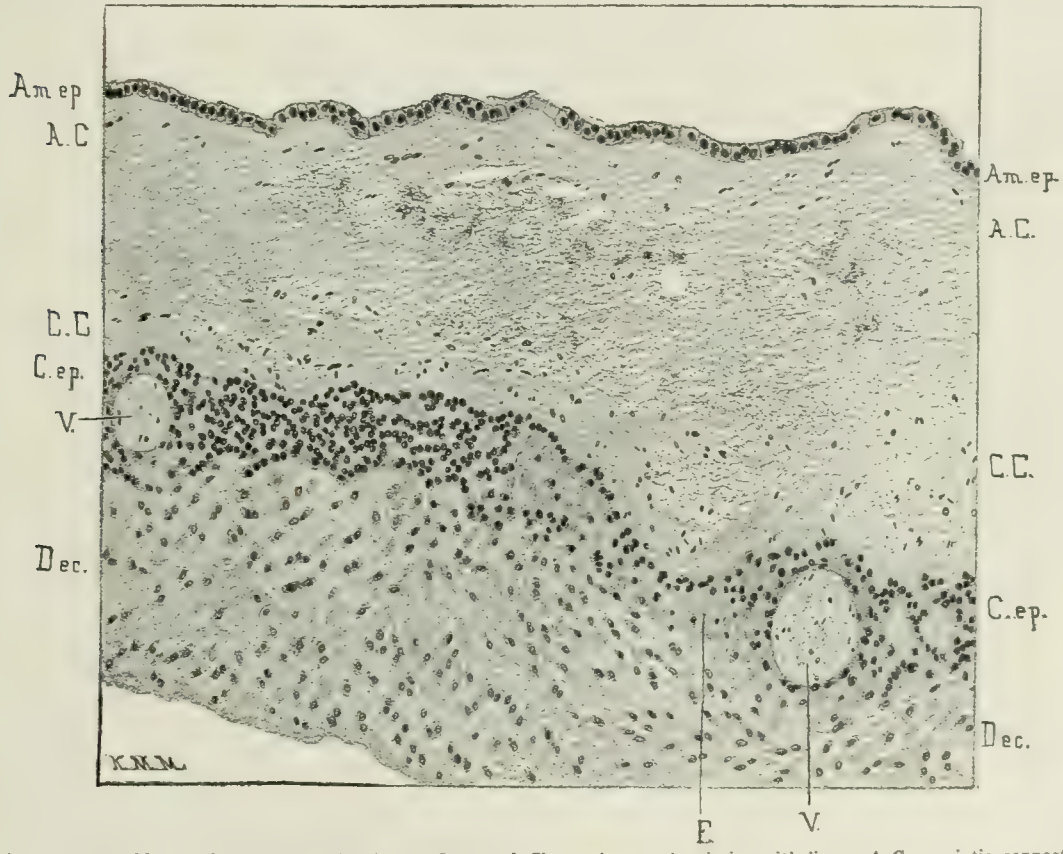


Fig. 1646.—Decidua and Membranes Outside of Placental Site. *Am ep*, Amniotic epithelium; *A C*, amniotic connective tissue; *C C*, chorionic connective tissue; *C ep*, chorionic epithelium; *Dec*, fused decidua vera and reflexa; *V*, degenerated chorionic villi. (From William's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

Decidua Basalis or Serotina.—The decidua basalis is the portion of the uterine mucous membrane which lies immediately beneath the ovum and is in contact with the chorion frondosum; it is by the union of these two structures that the placenta is formed. The chorion frondosum forms the fetal, and the decidua basalis the maternal contribution to the placenta.

Generally speaking, the decidua basalis presents the same general structure as the vera, except that it never attains the same thickness, and rarely exceeds three millimeters. As pointed out in the article upon the *Chorion*, after the first few days of pregnancy the decidua basalis does not consist entirely of decidual cells, but is invaded by large numbers of cells derived from the trophoblastic layer of the ovum, and accordingly its superficial portions are composed of a mixture of decidual cells and fetal ectoderm. On casual examination it is extremely difficult to distinguish between

The decidua basalis is traversed by a large number of blood-vessels which are concerned with the uteroplacental circulation. Both arteries and veins pursue a spiral course through the upper portion of the decidua, and finally lose their muscular coat, appearing as channels lined with endothelium. The arteries open into the intervillous spaces at points near the so-called decidual septa, which are pillars composed of trophoblastic tissue that rise from the free surface of the decidua. The veins begin as funnel-shaped openings between the septa, that is, about the middle of the cotyledons of the placenta.

As the maternal blood courses through the intervillous spaces it is completely enclosed by fetal ectoderm. In a sense, therefore, the mother's blood during this time is outside of her own blood-vessels, yet it never enters the fetus. And, on the other hand, the fetal blood never enters the mother. The

two circulations are separate and distinct. The passage of material from one to the other always takes place through the walls of the chorionic villi.

While the decidua has no active part in the transmission of nutriment to the fetus, it does serve to some extent as a place of storage for some of the elements of fetal nutrition. In 1859 Claude Bernard demonstrated the presence of glycogen in the placenta of the rabbit. It is also found in the human placenta, and is confined, as Driessen has proved, to the decidual cells. The glycogen is more abundant during the early months, decreasing gradually as pregnancy advances. On somewhat less satisfactory evidence it is believed that the decidual cells are concerned with the fat and, possibly, the iron metabolism of the fetus (Hofbauer).

In the third stage of labor the placenta and membranes become separated, and are expelled from the uterus. With these structures there is also cast off the greater portion of the decidua. The line of separation corresponds to the spongy layer of the decidua which from a mechanical standpoint, obviously, is the weakest region. The quantity and the character of the tissue lost has been accurately determined by means of microscopical examination. Thus, we have learned that the fetal surface of the placenta and the membranes is covered by a thin layer of maternal tissue, which corresponds to the compact layer and the upper portion of the spongy layer of the decidua. A still further loss occurs with the lochial discharge during the first few days of the puerperium. The deeper portion of the spongy layer, however, always remains behind, and from this the endometrium is regenerated.

The comprehensive and painstaking studies of Wormser have demonstrated that by the end of the second or third week of the puerperium the restoration of the endometrium has been completed. But for some time the surface epithelium continues to show localized areas of degeneration and regeneration. Usually these alterations cease and the process of restoration is concluded by about the sixth week after delivery. J. Morris Slemons.


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(See also article on the Chorion.)

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**Decidua, Pathology of the.**—The pathological changes occurring in the decidua during the course of pregnancy are but little known, although they play a very important part in the production of abortion and in various pathological conditions of the fetus. The majority of the decidual changes which have been described as pathological have been in reality physiological phenomena. It must be borne in mind that the decidua, as well as the chorion, is to be regarded in the latter months of pregnancy as a senile structure which presents various evidences of physiological degeneration. Many of these, such as fatty degeneration, calcification, thrombosis, etc., have been mistaken for signs of disease, and the literature of decidual pathology is largely made up of such misconceptions. The true pathology of this membrane remains for the greater part an unexplored field.

Physiological Changes.—As in the case of the chorion, the earliest changes of senility occur in the vessels. As early as the seventh month large thrombi are formed in the subplacental sinuses. These grow slowly toward the serotina and the intervillous spaces, but rarely extend far into the latter. The number of sinuses thus thrombosed is always relatively small under normal conditions. Giant cells are usually found in the veins so affected, appearing as early as the fifth month. These may be few in number or may completely fill the lumen of the vessel. Friedländer regarded these giant cells as being of decidual origin and entering the sinuses by diapedesis. After entrance into the vessels he believed that they adhered to the endothelium and induced the thrombosis. Further, he held that the progressive stagnation of the blood in the maternal sinuses led to a deficient oxygenation of the fetal blood which became the exciting cause of the onset of labor. Other writers believe that the giant cells arise either from the syncytial layer of the chorion, or from the endothelium of the sinuses. During the latter months of pregnancy there is a proliferation of the intima in many of the subplacental vessels leading to the gradual obliteration of a certain number of the sinuses, even before the beginning of labor. Since the subplacental sinuses are as much temporary structures as is the placenta itself, they are unnecessary after labor; and like the placenta, they begin to show signs of their disappearance and decay as early as the seventh month.

Aside from the thrombosis occurring in some of its cavernous spaces, the deeper layer of the serotina does not show much change in the last months. Its cells are somewhat smaller than in the earlier stages, and are more closely packed together. Scattered areas of fatty degeneration are found in them. The upper compact layer shows more change. Its nuclei have largely disappeared, and the cell outlines are indistinct. With ordinary stains it is difficult to distinguish the boundary line between the decidua and the overlying fibrin deposit; but with Weigert's fibrin stain the necrotic cells of the uppermost layer are shown to be surrounded and separated from each other by a delicate line of fibrin. The source of this intercellular fibrin is not yet clear, though it is claimed by many to be a product of the cell degeneration. Simple necrosis, liquefaction, fatty degeneration, and a colloid-like change may all be found in the decidual

cells of the upper layer and in those of the processes extending into the chorion. Lime salts are not infrequently deposited in such degenerated cells. Small areas of leucocyte infiltration are occasionally seen scattered throughout the lower portion of the compact layer. They are, however, much less numerous than in the young serotina. The degenerative changes are most marked in the superficial layer of cells, which may be almost entirely replaced by fibrin. Beneath this the change is less advanced, and well-preserved decidual cells may be seen. It is apparent from the careful study of these changes that they begin in the most superficial layers, and gradually extending deeper involve the whole of the compact layer. On the serotinal surface there lies usually a thick layer of fibrin derived from the maternal blood. The superficial cells of the decidual processes extending into the chorion suffer a similar necrosis, and there is a formation of fibrin about and between them. The cells in the inner portions of these processes undergo a liquefaction necrosis, resulting in the formation of cystoid spaces filled with a finely granular material.

It is evident that the degeneration of the compact layer of the serotina is coincident with the thrombosis of the subplacental sinuses, and that the two processes advance together, increasing toward term. In the last stages the placental arteries, as well as the venous sinuses, become obliterated or obstructed, and the degeneration of the serotina advances most rapidly during this time. There can be no doubt that the decidual degeneration is brought about by these vascular changes in the same way that chorionic infarction is dependent upon the changes in the chorionic vessels. It is to be noted, however, that in the chorion the small arteries are first affected, while in the case of the serotina the primary and chief changes are in the venous sinuses. The non-fibrinous infarct of the chorion may possibly be explained by the late thrombosis of the placental arteries. As a result of such thrombosis some of the intervillous spaces are deprived of blood, and the neighboring villi are crowded together to such a degree as to obliterate the intervillous spaces and to obstruct the circulation in the vessels of the villi. These changes lead to necrosis of the affected villi without an intervillous formation of fibrin.

Nodules or diffuse patches of decidua-like cells occur upon the pelvic peritoneum and in the ovary during the early weeks of pregnancy, but are most pronounced after the fourth month. They often persist long after normal delivery, and disappear by normal retrograde changes. They occur in both intra- and extrauterine pregnancy.

Circulatory Disturbance.—The condition of the circulation in the subplacental vessels and serotina is largely dependent upon the general state of the maternal circulation. In anemias and various forms of general hyperemia of the mother the circulation in the maternal placenta will show a similar condition. Local anemia and congestion of the placental arteries and sinuses may be the result of partial obstruction or obliteration of certain of the vessels, or they may be secondary to pelvic or portal congestions. Hemorrhage from the decidua is of frequent occurrence. It may follow the death of the fetus and the subsequent detachment of the placenta, or it may be the exciting cause of such detachment. It is in many instances impossible to fix the true relation existing between hemorrhage and abortion. The causes of decidual hemorrhage are manifold: trauma, external violence, mechanical attempts at abortion, maternal congestions, thrombosis of placental sinuses, rupture of the blood spaces of the serotina, excessive heart action, syncope, maternal albuminuria, syphilitic changes in the decidua, decidual hyperplasia, endometritis decidualis, etc. Large hemorrhages into the decidua may occur during labor. These are especially dangerous in the case of placenta prævia. In the early months of pregnancy the hemorrhage is most frequently due to rupture of the thin-walled blood-vessels surrounding the chorionic villi. The large collections of blood and blood clot found so frequently in the intervillous spaces, the so-called "placental apoplexy," are not in reality a hemorrhage since the blood lies in a blood space. In many cases the condition represents only an extreme congestion of a portion of the intervillous spaces, while in others the collection of blood may be due to a true hemorrhage into the intervillous spaces arising from ruptured vessels in the serotina. Some of the so-called "red infarcts" are apparently formed in a similar manner. Occasionally extravasations may burrow down between the layers of the decidua and escape from the uterus. The effects upon the fetus will depend upon the amount of blood extravasated. In large hemorrhages the villi may be compressed and the fetus asphyxiated, or the placenta may be partially or wholly stripped from the uterine wall, and the fetus prematurely expelled. Smaller hemorrhages may lead to disturbances of fetal development without causing its death. Such an extravasation may become organized, partly absorbed, or encapsulated. In the latter case the liquefaction of the clot gives rise to a cyst which contains either a red, a brown, or a clear fluid.

After the death of the fetus the placenta may be retained for a long period of time. If hemorrhages occur into the membranes with clotting of the blood thick deposits of fibrin may be formed on and between the layers, leading to the production of a flesh-like mass which is known as *fibrin mole* or *fleshy mole*. The formation of such a mole may begin before the death of the fetus, and may be the exciting cause of abortion. If the dead fetus is not expelled it may be absorbed; after this the growth of the fetal membranes may continue with or without successive hemorrhages. In the latter case a solid flesh-like cast of the uterine cavity, made up of fibrin and remains of the fetal membranes, may ultimately be expelled. A similar process may take place in the case of retained placenta after delivery at full term, but it is of most frequent occurrence in the earliest stages of pregnancy. In tubal pregnancy a characteristic *decidua uterina* is formed, but is expelled during the early weeks of the pregnancy, and thus serves as an important sign of tubal pregnancy. It may appear as a thick fleshy cast of the uterine cavity, and microscopically shows a simple hyperplasia of decidual tissue without the adenomatous hyperplasia of the glands seen after uterine abortion and retention of the decidua.

Retrograde Changes.—Atrophy of the decidua has been described, but is of rare occurrence. Either the decidua serotina, or vera, or reflexa may show this change, singly or coincidently. As a result of such atrophy the ovum may be attached to the uterine wall by a slender pedicle, which may become so stretched that the ovum comes to lie in great part within the cervical canal. In other cases its membranes may rupture and its contents be discharged from the uterus. The changes taking place in the atrophic membrane are similar to those occurring in the decidua reflexa in the physiological atrophy of this portion of the decidua in the latter months of pregnancy. The retrograde changes, such as fatty degeneration, necrosis, calcification, etc., which occur as physiological changes in the last months, may have pathological significance when they appear at an earlier period or are more extensive than usual. They are usually the result of a premature thrombosis of the subplacental sinuses, and are found especially in connection with maternal syphilis, nephritis, and other cachexias. Local inflammatory changes in the endometrium, hyperplastic conditions of the

decidua, etc., likewise lead to a premature degeneration of the serotina. These changes when extensive and when occurring at an early stage of pregnancy may lead directly to death of the fetus and abortion, but, as a rule, they give rise to hemorrhages which become the direct exciting cause of abortion. Pathological fatty degeneration never occurs in the decidua to any great extent, though slight degrees of this change are frequently present in the physiological decay of this membrane. Necrosis—both the simple form and liquefaction necrosis—is the most common retrograde change found in the decidual membranes. By many writers the death of the decidua is regarded as being more of the nature of a coagulation necrosis in which fibrin is formed from the degenerating decidual cells. It is, however, more probable that the fibrin is derived from the maternal blood, being formed upon and between the cells, so that the necrosed cells come to lie in a network of fibrin which completely replaces the intercellular substance. The cells themselves do not stain like fibrin, but in the majority of cases have a hyaline appearance and stain in a manner similar to colloid (so-called hyaline degeneration). As the intercellular fibrin contracts the cells become smaller and gradually disappear. Premature necrosis of the superficial layer of the serotina occurs, especially in syphilis acquired during the early months of pregnancy and in albuminuria. Calcification rarely is extensive enough to possess pathological significance, but occurs more frequently in syphilis, albuminuria, etc. Deposits of blood pigment may occasionally be found as the remains of old hemorrhages.

Progressive Changes.—Hyperplasia of the decidua not infrequently occurs in the form of diffuse or circumscribed thickenings. The latter are most common, and are usually associated with chronic endometritis. The general thickening occurs in association with defective development of the fetus. Nodular and diffuse fibrous thickenings have also been described. The physiological atrophy and blending of the decidua reflexa with the vera may not take place, and the former remains as a distinct and thickened membrane. These changes are considered by many writers to be of inflammatory origin. Hemorrhages and various retrograde changes are usually associated with the different forms of hyperplasia. After abortion the retained decidua usually becomes hyperplastic (so-called deciduoma or decidual adenoma). The glands take on the appearances of an adenoma, often papilliferous, while between the hyperplastic glands small islands of decidual cells can be seen grouped about small hyaline blood-vessels (*subinvolutio deciduæ*).

Fig. 1647.—Subinvolutio Deciduæ. An island of decidual cells in the midst of tissues of the endometrium which have undergone complete involution. (After Gebhardt.)

Inflammation.—In the early months of pregnancy small areas of leucocyte infiltration are very frequently found in the lower layer of the serotina. In the later stages of development they are less common. Purulent inflammation of the decidua during the course of pregnancy is not of rare occurrence. It may be the result of gonorrheal infection or of infection with pyogenic organisms following attempts at abortion or during prolonged labor. In these cases pus may be formed in the serotina and vera as well as in the chorion; a thin layer of pus covering the entire vera is sometimes found. The small-cell infiltration is found usually only in the superficial layer, while at a greater depth only isolated collections of leucocytes are seen. Acute inflammation of the decidua may occur in the course of cholera and other infections, especially in the exanthematous diseases; also, following attempts at abortion, trauma, etc. In cholera the decidua may be thickened, of a dark purple color, and contain numerous extravasations of blood (endometritis decidualis hæmorrhagica). It is probable that the same condition may be found in other acute infections. In the exanthemata premature expulsion of the fetus not infrequently occurs at the time of the appearance of the eruption, and this has been explained by Klotz as being the result of an exanthematous inflammation of the endometrium and decidua.

The *chronic forms* of decidual inflammation are more frequently seen. They partake more of the nature of hyperplasias than of true inflammatory processes. They form the most common pathological condition of the placenta, and are the most frequent cause of abortion. In general, they are characterized by an overgrowth of the decidua or some of the constituent elements of the endometrium. The origin is almost always from a pre-existing endometritis, of either gonorrheal, or syphilitic, or non-infective nature. In some cases the death of the fetus may be the exciting cause, the decidual changes being secondary to this event. Five forms of chronic decidual endometritis occur; the diffuse, polypoid, catarrhal, adenomatous, and cystic. In the diffuse form there is an increase in all of the elements of the decidua leading to the formation of a membrane many times thicker than the normal decidua. In the case of

Fig. 1648.—Endometritis Decidualis. Marked small-cell infiltration of the uppermost layers of the decidua. (After Gebhardt.)

rapid hyperplasia death of the embryo may occur as the result of deficient nutrition, or extensive hemorrhages into the hyperplastic decidua may take place, either separating the membrane from the uterine wall or breaking through it into the fetal membranes. The embryo may be absorbed and the decidua and remnants of fetal membranes, together with masses of fibrin, may be expelled later as a fleshy mole. If the hyperplasia is of slow development pregnancy may go on to full term, and a living child be delivered. Various evidences of deficient development are, however, very common in these cases. The hyperplastic decidua shows a great increase in the number of decidual cells, many of which are spindle-shaped, resembling connective tissue more closely than decidua. Areas of fibrous connective tissue are found throughout the membrane, and newly formed unstriped muscle is described as occurring. Either the cellular or the connective-tissue hyperplasia may predominate. If the latter takes place to a very marked degree the condition may be termed scirrhous inflammation of the decidua. The effects of chronic decidual endometritis upon both mother and fetus are very important. The hemorrhages may prove fatal to the former as well as to the latter. After the expulsion of the fetus portions of the hyperplastic decidua usually remain attached to the wall, and, these continuing to grow, may either give rise to further hemorrhages or to the development of a malignant tumor, or through decomposition produce toxemia, or lead to infection.

In the *polypoid form* there is in place of the diffuse thickening a localized hyperplasia in the form of scattered nodules or outgrowths (endometritis decidualis polyposa s. tuberosa). On the inner surface of the decidua there are villous-like projections two to five centimeters in length, very vascular, and having a smooth surface. Between these may be seen the openings of the uterine glands, many of which are greatly dilated. The entire membrane is thickened, and there is an apparent new formation of blood-vessels. On microscopical examination the outgrowths are found to consist of decidual cells, many of which are larger than usual and possess very large nuclei. Bands of connective tissue are found throughout the membrane, especially about the glands and blood-vessels. This form occurs only in the early stages of pregnancy, and is frequently associated with a myxomatous degeneration of the chorion. Abortion usually occurs before the fourth month. Syphilis was formerly supposed to be the cause of this disease, but it is found in cases of chronic endometritis in which no syphilitic history can be obtained. The gonococcus has been found in a number of cases.

A *catarrhal endometritis* may either prevent conception or hinder the development of the fertilized ovum in the uterus through deficient formation of the decidua. The vera and reflexa may fail to unite, and the serotina may be very small or attached to the ovum in the form of a pedicel. The catarrhal secretion of the uterine glands in the shape of a thin, watery mucus may collect between the vera and reflexa, preventing their union (hydrorrhea gravidarum). This fluid may be expelled from the uterus in sudden gushes, or it may dribble away for a long time without seriously affecting the course of pregnancy. If a large quantity of fluid collects, uterine contractions are usually set up and abortion results. The condition is rare, occurring more frequently in multiparæ, and begins usually in the third or fourth month.

The *adenomatous form* of decidual endometritis takes its origin from cases of chronic glandular endometritis. With the beginning of the formation of the decidua there is at the same time a glandular hyperplasia which may be so marked as to assume the character of an adenoma. It may be general or localized. This change takes place very early, and leads very quickly to abortion. The endometrium is greatly thickened; on microscopical examination the surface of the endometrium is seen to consist of a thin layer of decidua beneath which lie the hyperplastic uterine glands. The latter are greatly enlarged and increased in number with but little intervening stroma, so that the appearance of an adenoma is presented. A similar condition occurs in the case of retained decidua after abortion or delivery, very frequently in cases of subinvolution. If there is an excessive secretion in the glands, and if this is prevented from escaping, cystic dilatation of the gland spaces may result (endometritis decidualis cystica). In these cases the decidua is thickened from an increase of decidual cells, connective tissue, and fibroblastic tissue. Numerous small cysts are scattered through it, corresponding to the dilated glands. The cystic form is found only in the early stages of pregnancy, but it is probable that it precedes the diffuse hyperplastic form, the glands being obliterated as the process advances.

The *prognosis* in all forms of chronic decidual endometritis is very unfavorable for the fetus, and not wholly favorable for the mother. The disturbance of fetal nutrition and the tendency to hemorrhage render the chances of escape from abortion very slight. As a result of the firmer attachment of the decidua to the uterine wall, retention of the membrane after abortion or delivery is especially likely to occur; and in this lies the source of greatest danger to the mother in the form of repeated hemorrhages and infection following the necrosis of the retained material.

*Treatment* during pregnancy is of course impossible. Since the cause of these chronic forms lies in a pre-existing chronic endometritis their prevention should be attempted through the cure of the latter. The gonococcus is probably the most important etiological factor, either directly or by paving the way for secondary infections. The treatment of gonorrhea will be, therefore, the chief means of prevention of these conditions.

Endometritis Decidualis Post-Abortum s. Post-Partum. -(*Retentio deciduæ, Subinvolutio deciduæ*). After normal termination of pregnancy the decidua undergoes an involution into the normal uterine stroma. This involution under normal circumstances progresses uniformly over the entire endometrium. Under certain conditions, the causes of which are as yet unknown, portions of the decidua fail of involution and retain their character long after the expulsion of the fetus and placenta. This is of much more frequent occurrence after abortion, in which case portions of the chorion are usually retained. Persistence of the decidua may, however, occur without retention of the fetal membranes, though this is questioned by some writers. On the other hand, retention of the chorion is always associated with persistence of the decidua. Though the name retentio deciduæ has been applied to this condition, it is properly a subinvolution (*subinvolutio deciduæ*) and not a retention, as under normal circumstances the entire decidua is not expelled from the uterus but becomes changed back into uterine stroma. To the naked eye the endometrium shows but little change in some cases, but often it is diffusely or irregularly thickened, and may present a polypoid appearance. Under the microscope two different forms may be distinguished, but these are frequently combined. In the first form, groups of large decidual cells are found scattered through the stroma of the endometrium which has resumed its normal character. The cells in the central portion of the groups are the largest, and best preserve their decidual characteristics, while those at the periphery are smaller and pass gradually into the surrounding stroma tissue so that no definite point of transition can be made out. The groups of decidual cells lie for the greater part in

the upper layers of the endometrium, but are covered by surface epithelium from which they are separated by a more or less thick layer of stroma. They usually surround a group of small thick-walled blood-vessels, the walls of which show more or less hyaline change. The presence of fibrin can occasionally be demonstrated in these decidual islands. The cells may preserve their decidual character for months after the abortion. This form of retention of the decidua is distinguished from those forms of chronic endometritis in which the stroma cells increase in size and more or less resemble the decidual cells, by the fact that the true decidual cells lie in groups and are not diffusely scattered throughout the entire endometrium. In the second form the decidual cells lie in the lower portion of the endometrium, extending even into the muscle and into the walls of the blood-vessels. This form is easily distinguished from the changes of chronic endometritis by the relation of the decidual cells to the large blood-vessels, as in chronic endometritis changes of this kind do not take place. In both forms of retentio deciduæ the endometrium shows either a glandular hyperplasia or an interstitial inflammation. In many cases it becomes impossible to decide as to which is the primary process. The frequent and severe hemorrhages which form the chief symptoms of retention cannot be explained by the microscopical findings. In the early stages of retention of the fetal and decidual membranes infection with saprophytic or pyogenic organisms is likely to occur, giving rise to either putrid or septic inflammatory processes (endometritis puerperalis putrida s. septica). The putrid form is caused by various anaërobic bacteria, the *Proteus vulgaris*, colon bacillus, etc.; the septic form is dependent chiefly upon the streptococcus and staphylococcus. The latter condition not infrequently assumes the character of a diphtheritic inflammation.

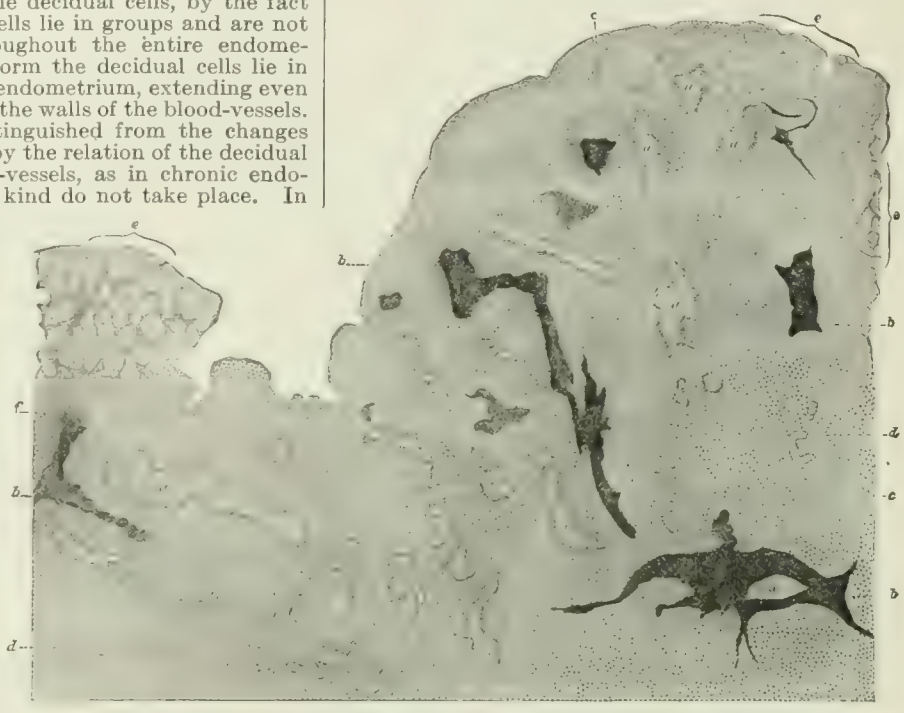


Fig. 1649.—Benign Deciduoma; Section of Periphery of Tumor. *a*, Glands; *b*, blood spaces; *c*, lymph sinus; *d*, arteriole; *e*, capillaries; *f*, junction of capillaries and blood space; *g*, island of decidual tissue in blood space. (After Klotz, *Arch. f. Gyn.*, vol. xxix.)

Tuberculosis.—Tubercle bacilli have been demonstrated in the placental sinuses when no tuberculous lesions were present in the placental tissues. In the case of decidual formation in a tuberculous endometrium the tubercles may gradually invade the decidua and later the chorion. In acute miliary tuberculosis of the mother areas of caseation containing tubercle bacilli may be found in the decidua associated with a thrombosis of the sinuses. The presence of numerous disintegrating leucocytes in the caseous areas and thrombi gives them a diffuse blue stain with hematoxylin that distinguishes them from the physiological thrombosis of the sinuses. Typical epithelioid tubercles are not produced in the decidua, and giant cells occur rarely in the areas of caseation that characterize decidual tuberculosis. The descriptions of the condition given in the literature all agree in regard to this feature. It would appear that the highly specialized decidua is unable to produce fibroblastic or epithelioid cells in response to a local injury caused by tubercle bacilli, the process not progressing beyond the primary necrosis and thrombosis caused by the action of the bacilli upon the wall of the decidual sinus at the point where they may lodge.

Syphilis.—Almost all of the physiological changes, such as fatty degeneration, calcification, etc., have been ascribed to syphilis. The changes in the subplacental sinuses have likewise been considered to be due to the same cause. There is, however, no definite relation between the occurrence of these changes and syphilitic infection. They bear the same relation to nephritis and other cachexias, in that in all of these conditions they are more extensive than they should be normally. It is to be noted that in well-marked cases of syphilitic infection, both of mother and of child, no changes may be found in the decidua. Further, the syphilitic nature of many of the supposedly specific changes in the decidua is very doubtful. A diffuse hyperplastic endometritis serotina has been described. The decidua is thickened, cloudy, and yellowish in color, and its consistence is greatly increased. In its general character this form of decidual hyperplasia (endometritis decidualis syphilitica) cannot be distinguished from the hyperplastic form of decidual endometritis occurring without syphilis. It is probable that the relation is one of coincidence. A form of decidual hyperplasia associated with the development of gummata (endometritis decidualis gummosa) has also been described by a few observers. Throughout the hyperplastic decidua there are scattered miliary or larger nodules which have a caseating center with a periphery of leucocyte infiltration or connective tissue. The larger nodules are for the greater part composed of firm connective tissue or granulation tissue, in the center of which there is a finely granular detritus. It is probable that fibrin masses, placental infarcts, necrotic areas, etc., have been mistaken for gummata, as the descriptions given in some of the reported cases are not conclusive. In a general way the changes in

the maternal placenta that can be ascribed to syphilis are of the same nature as those occurring in the fetal placenta; they are of the character of senile changes occurring either prematurely or to a much greater degree than normally. Of these, extensive thrombosis of the subplacental sinuses is the most important, as it gives rise to the retrograde changes in the serotina, and also most probably plays a part in chorionic infarction. Not one of these decidual changes is distinctive of syphilis, and new studies of decidual syphilis must be made, based upon the demonstration of the presence of the spirochete.

New Growths.—Hyperplastic conditions of the decidua are found in either a diffuse or a polypoid decidua, as reported in a limited number of cases, show a progressive growth, and do not tend to spontaneous expulsion or involution. Two forms of decidual neoplasms have been described in the literature, but so rarely that their true nature is doubtful, and we are justified in doubting their neoplastic character. The first of these is composed of decidual tissue and contains uterine glands or new glandular tissue derived from these. Its structure, therefore, resembles that of the serotina. This growth is analogous to the adenoma in its general manner of growth. It is benign, in that it does not produce metastases, but may recur after operation if not thoroughly removed. It does not undergo spontaneous involution or expulsion, but shows a progressive growth for

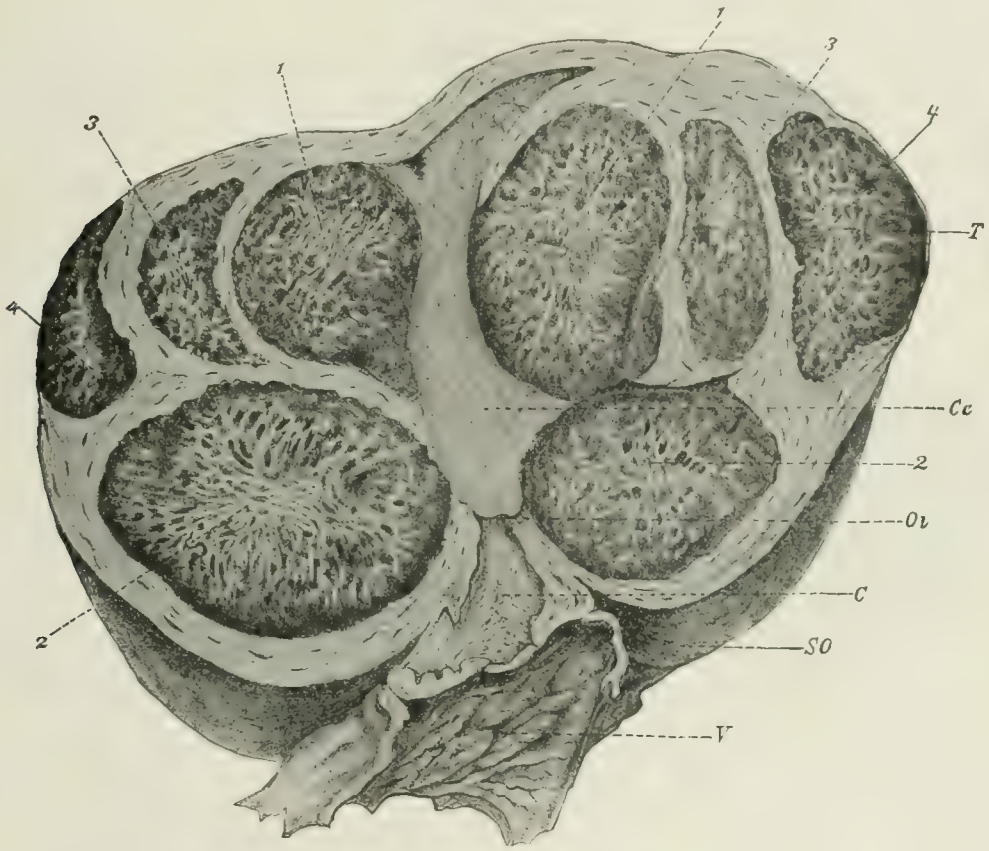


Fig. 1650.—Sarcoma Uteri Deciduocellulare. Uterus opened in the anterior median line, showing many tumor nodules (1, 2, 3, 4.) *T*, Tumor; *Cc*, uterine cavity; *Oi*, internal os; *C*, cervix; *V*, vagina; *SO*, serosa of uterus. (After Sänger, *Arch. f. Gyn.*, vol. xliv.)

form, before or after the expulsion of the fetus, but occurring most frequently in subinvolution of the decidua after abortion. They are also of frequent occurrence in the various forms of decidual inflammation of either specific or non-specific origin. To this class of simple decidual hyperplasia the majority of the so-called *decidual polyps* or *benign deciduomata* belong. It is doubtful if these should be regarded as neoplasms, but no distinct line of separation can be drawn between such simple hyperplasias and those whose overgrowth is so extensive as to warrant their being classed as tumors. They differ, however, from the true decidual neoplasms in that they are almost always spontaneously expelled, or undergo involution. If operated upon they do not recur, provided the removal has been complete. On the other hand, the true neoplasms arising from the months after the abortion or delivery which gave it origin. In a few cases a much longer period, from one to two years, has been observed. The growth takes its origin from the islands of decidual tissue found in subinvolution of the decidua. To this form the term deciduoma has been usually applied, but the simple inflammatory hyperplasias, subinvolutions, etc., as well as the new growths arising from the chorionic epithelium, have also been called by this name. Much confusion has therefore arisen out of the unsettled state of the terminology of the neoplasms arising from the decidua and chorion. In the majority of the latest text-books the term deciduoma is used as a synonym for syncytioma, though the latter tumor arises from the syncytial layer of the chorion, is epithelial in character, and has nothing in common with the decidua, which is of mesoblastic origin. To

clear up this confusion it has been suggested by Sänger that the term deciduoma be dropped, and the decidual neoplasm be known by the term, *decidual adenoma* or *adenoma deciduale*. It seems to the writer that this use of the word adenoma is also of danger in that a wrong conception of the structure of the decidual growth may be given, since the present use of the word adenoma is restricted almost wholly to epithelial tumors. It is most probable that the so-called benign deciduoma or adenoma deciduale is not a neoplasm, but only a hyperplasia or non-resolution of the decidua after an abortion. It has, therefore, only the significance of the *subinvolutio deciduæ* (see above). Clinically, this growth is characterized by severe hemorrhages, secondary infections, etc. The treatment consists of thorough and deep curetting. This will produce a cure, if malignant changes have not already taken place.

The second form of decidual neoplasm bears the type of a sarcoma and contains no glands. To it the name of *deciduosarcoma* or *sarcoma deciduocellulare* has been given. According to Sänger it possesses the structure of a sarcoma, consisting of large oval or spindle-shaped cells with occasional giant cells, and having a very scanty intercellular substance. The cells bear a very close resemblance to decidual cells, and in some cases the origin of these cells from the decidua can be definitely made out. The tumor may

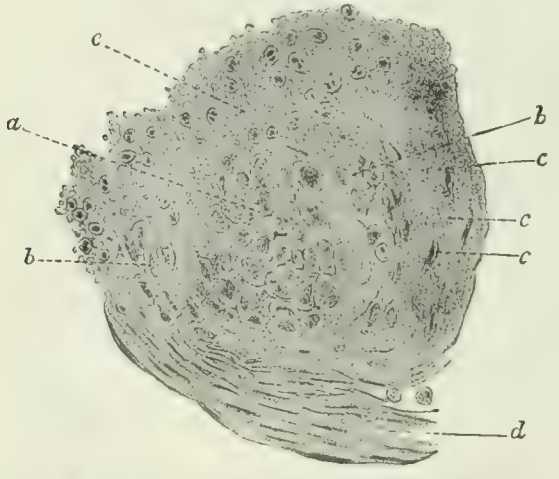


Fig. 1651.—Section of Tumor Nodule from Uterus Pictured in Preceding Figure (Sarcoma Uteri Deciduocellulare). *a*, Nest of decidua like cells infiltrating muscularis; *b*, *b*, smaller nests; *c*, intermuscular connective tissue; *d*, muscle; *e*, hemorrhage. (After Sänger's *Arch. f. Gyn.*, vol. xliv.)

form a diffuse growth over the endometrium or may develop scattered nodular masses. These frequently undergo ulceration. It may extend into the uterine wall by expansion or infiltration. Metastases are very quickly set up; these are most frequent in the vaginal walls and lungs. It is one of the most malignant forms of sarcoma on account of its rapid diffusion. Retention of the chorion with or without pathological changes in the chorionic villi may or may not take place in association with this growth. Clinically, this tumor is characterized by its development following delivery or abortion, severe hemorrhages, secondary infections, rapidly developing cachexia, evidences of metastases in lungs, etc., and very rapid course, the majority of the patients dying within six or seven months. The disease is very often mistaken for cancer or puerperal sepsis. The differential diagnosis must depend entirely upon the microscopical examination of portions of the growth removed from the uterus. Because of its very rapid growth a cure can be effected only by the earliest possible recognition of the condition and the removal of the uterus. The prevention of the growth may be accomplished by the complete removal from the uterus of all portions of retained placenta after delivery or abortion. This is of especial importance in the case of hydatid mole, since in many cases the decidual sarcoma appears to follow this condition. No similar findings are recorded in the recent literature, and it appears very probable that Sänger's sarcoma deciduocellulare is in reality a syncytioma malignum and not a decidual neoplasm. If this be the case it yet remains to be shown that a primary malignant tumor of the decidua exists. In the literature the term "deciduoma malignum" is used as a synonym for chorioepithelioma or syncytioma malignum.

Aldred Scott Warthin.

**Decocta.**—A decoction (*decoctum*) is a liquid preparation made by boiling a vegetable substance in water. The process of decoction is suitable to such drugs only as do not have their active principle or principles either decomposed or dissipated by the heat of boiling; but even in the case of decoctions of appropriate drugs, the preparation will spoil by keeping, unless, indeed, the original drug contain some antiseptic substance. Medicinally, decoctions are objectionable because bulky, ill-tasting, and necessarily containing other constituents of the original drug substance than the active principle. There are no decoctions official in the United States Pharmacopœia; but that work gives a general formula for the preparation of decoctions, as follows: "An ordinary decoction, the strength of which is not directed by the physician, shall be prepared by the following formula: take of the substance, coarsely comminuted, 50 grams; water a sufficient quantity to make 1,000 c.c. Introduce the substance into a suitable vessel provided with a cover, pour upon it 1,000 c.c. of cold water, cover it well, and boil for fifteen minutes. Then allow it to cool to about 40° C. (104° F.), express, strain the expressed liquid, and pass enough cold water through the strainer to make the product measure 1,000 c.c. *Caution.*—The strength of decoctions of energetic or powerful substances should be specially prescribed by the physician." (U. S. P.) The average dose of a decoction prepared by the above formula is from one to two fluidounces.

The National Formulary and the British Pharmacopœia each include three decocta:

| Name. | | Ingredients. |
|---|---|---|
| Decoctum aloes compositum (compound decoction of aloes). | N.F., and B.P. | Extract of aloes, myrrh, saffron, potassium carbonate, extract of glycyrrhiza, compound tincture of cardamom, and water, |
| Decoctum cetrariæ (decoction of cetraria). | N.F. | Cetraria, and water. |
| Decoctum granati corticis (Decoction of pomegranate bark). | B.P. | Pomegranate bark, and water. |
| Decoctum hematoxyli (Decoction of logwood). | B.P. | Logwood, cinnamon bark, and water. |
| Decoctum sarsaparillæ compositum (compound decoction of sarsaparilla). | N.F. | Sarsaparilla, sassafras, guaiacum wood, glycyrrhiza, mezereum, and water. |

Edward Curtis.
R. J. E. Scott.

**Deep Rock Spring.**—Oswego County, New York.

Post-office.—Oswego. Hotel.

Oswego is located on Lake Ontario, about fifty

miles south of the head of the St. Lawrence River. It is reached by the Delaware, Lackawanna and Western, the New York, Ontario and Western, and the New York Central railroads. The Deep Rock Spring was opened to the public and the water placed on the market in the spring of 1871. The following analysis was made by A. Richter, Ph. D., consulting and analytical chemist of New York:

HYPOTHETICAL COMBINATION.

| | |
|---|---|
| Ferric oxide | 0.320 |
| Ammonium chloride | 0.294 |
| Silica | 14.800 |
| Calcium phosphate | trace |
| Lithium chloride | trace |
| Potassium chloride | 11.100 |
| Sodium chloride | 2,198.400 |
| Sodium nitrate | 61.300 |
| Sodium nitrite | trace |
| Sodium bicarbonate | 226.800 |
| Magnesium bicarbonate | 19.700 |
| Calcium bicarbonate | 55.400 |
| | 2,599.574 |

SANITARY ANALYSIS.

| | |
|---|---|
| Ammonia, free | trace |
| Ammonia, albuminoid | 0.054 |
| Nitrogen as nitrites | 0.0008 |
| Nitrogen as nitrates | 1.254 |
| Organisms per c.c. on agar after 48 hours incubating at 25° C | 60,000 |
| Organisms per c.c. at 37° C | 2,550 |
| No gas-forming organisms; no coli bacilli; no streptococci. | |

The water is strongly saline and actively diuretic without cathartic effects. It is useful in rheumatism and some forms of kidney and bladder troubles. It is claimed that the water contains a greater proportion of potassium chloride than does any other known spring. A valuable sulphur spring has been discovered in a ledge of rocks fifty-seven feet above the source of Deep Rock, and it is intended to utilize this for both drinking and bathing purposes. The city of Oswego offers unusual attractions as a place of residence during the summer.

EMMA E. WALKER.

**Defecation.**—The residue of food digestion and other débris from the alimentary canal, after accumulating in the colon and sigmoid flexure, are discharged at more or less regular intervals. This discharge constitutes defecation. The rectum is ordinarily a closed tube, the descent of fecal matter into it being prevented by the so-called third or superior sphincter. Its distention by fecal matter produces the normal stimulus to peristaltic contraction and a sensation which is recognized by the individual as a call for evacuation. If the call be not promptly responded to, the rectal contents pass back, probably by a reversed peristalsis, into the sigmoid flexure, and the desire for evacuation temporarily ceases. Ordinarily the call is repeated at short intervals and with increasing urgency until it is responded to; habitual neglect of it begets a tolerance, and the rectum becomes also a reservoir of fecal matter, and its evacuation as a result becomes difficult.

From this it is evident that defecation is largely under the control of the will, but it is not wholly so. It is, in fact, a reflex, involuntary act, aided or prevented, as the case may be, by voluntary impulses. The extrusion of fecal matter is accomplished chiefly through the peristaltic movement of the bowel, both longitudinal and circular muscular coats taking part in it. The contraction of the circular fibers produces the peristaltic wave, while that of the longitudinal fibers gives support to the rectum and tends to diminish its length. The anal orifice is guarded by two sphincters, the outer one a voluntary muscle, the inner involuntary, being formed by a strong band of the unstriated circular coat of the bowel. The external sphincter is composed of striated fibers; but it is only to a certain extent under control of the will, for it relaxes when the impulse to evacuate becomes imperative. The musculature of the rectum is under the control of both motor and inhibitory nerve fibers. Some of these fibers come from the lumbar plexus and others from the sympathetic ganglia of the region, the inferior mesenteric and the hypogastric plexuses. The physiological center in the lumbar cord is known as Budge's centrum anospinale. There exists also a nervous connection with one or more cerebral centers. There is, undoubtedly, an inhibitory center, supposed to lie in the optic thalami, whose action is in part at least to prevent the reflex closure of the sphincter under the stimulation of the sensory nerves of the rectum by the descent of feces. In the infant defecation is probably entirely involuntary. In certain diseases of the brain or spinal cord, in sleep, or in intoxication, involuntary evacuation sometimes occurs and certain psychic or emotional states, as of fright or fear, are capable of inducing it. Such accidents are attributable either to the removal of some cerebral control or to the action of the inhibitory center.

Defecation begins ordinarily with the voluntary inhibition or withdrawal of the action of the external sphincter. This inhibition is of limited duration, however. It may be terminated voluntarily, but it cannot be continued indefinitely by the action of the will; a rather sharp contraction, as a rule, follows the passage of a fecal mass. Relaxation of the sphincter is accompanied by a contraction of the abdominal muscles and a variable action of the diaphragm, corresponding to the amount of expulsive force required. The sensation produced by the distention of the rectum is peculiar and should not be disagreeable, but in some diseased conditions of the bowel it becomes exaggerated into a painful tenesmus. If the peristaltic action has been strong and the demand for evacuation imperative, the diaphragm is not necessarily brought into requisition, but when additional force is required, as in constipation, the diaphragm is depressed, causing full inspiration, and its ascent is prevented by a closure of the glottis. In this way and by the subsequent contraction of the abdominal muscles, not only is the rectum emptied, but the passage of the contents of the descending and sigmoid colon into the rectum is assisted. Defecation is assisted also by the levator ani muscles, whose contraction tends to draw the sphincters upward over the fecal mass. The rectal peristalis can be increased also by repeated voluntary contractions of this muscle and the external sphincter. During defecation the mucous membrane of the anus is slightly everted, especially when the expulsive force is strong. After the completion of defecation the sphincters relax to some extent, as their contraction is not required to retain the closure of the anus in the intervals between the acts of defecation.

It is generally admitted that defecation should occur once in twenty-four hours, yet it may occur twice or thrice within that limit of time or only once in two or three days with apparently normal regularity. Its frequency is largely a matter of habit with the individual. In cases of habitual constipation evacuations may occur as seldom as once in a week, but in inflammatory diseases of the intestine they may occur at intervals of only a few minutes. The frequency and character of defecation are often valuable factors in diagnosis.

The results of recent studies of abdominal conditions by means of $x$-ray bismuth pictures, sigmoidoscopy, laparotomy findings, etc., render it highly probable that various mechanical factors oppose defecation, even in the presumably healthy. The rectum is capable of great elongation in atony of the colon and

its position in the pelvis may be such that Lane compares it to a cesspool. Some bismuth pictures appear to show that normal defecation is preceded by a large pear-shaped accumulation of feces in the sigmoid, which is fully expelled at once. "Fractional" defecation is usually due to a columnar accumulation of fecal matter in the transverse colon.

JAMES M. FRENCH.
EDWARD PREBLE.

**Degenerations and Deposits.**—Among the most important disturbances of metabolism are those classed as the degenerations and the deposits. While the term tissue-degeneration is very often applied to all kinds of retrograde changes, it is also used in a specific sense to indicate that particular class of metabolic disturbance which is characterized by the formation of abnormal substances out of the cell protoplasm or by the chemical deconstitution of the latter so that normal substances are formed in excess or are not used up normally. These substances may be retained within the cell or discharged from it. Any pathological increase in the production of substances normally manufactured by the cell or forming an essential element of the cell-protoplasm would also be included under this head. To avoid the confusion arising from the loose use of the term degeneration, it might be of advantage to class these changes as the *true degenerations*. The *deposits* or *infiltrations*, on the other hand, are characterized by the deposit in the cells or tissues of normal or pathological substances which have either formed within the body or have been introduced into it from without. The deposit is often a result of degeneration either at the point of deposit or elsewhere in the body, or it alone may represent the chief feature of the pathological change. It is very difficult sometimes to draw a distinct line between degeneration and deposit, since identical or similar substances may be formed within the cell out of its own protoplasm or be brought to it, and deposited either in it or about it. Some substances such as fat, melanin, glycogen, etc., thus play the rôle of both degeneration and deposit; while others such as mucin, pseudomucin, amyloid, etc., occur in but one form, either that of a degeneration or that of a deposit as the case may be. Many of the substances which are regarded as deposits are usually found in or near the walls of the smaller blood-vessels, suggesting the possibility of their formation through changes in the secreting cells of the vessel wall. The new substances are either taken out of the blood by the endothelial cells or are formed by the protoplasm of the latter, and passed out into the lymph spaces of the surrounding tissue after the manner of a secretion. Both amyloid and hyalin appear to be formed in this way. As ordinarily used degeneration is the broader term including both the true degenerations and the deposits, the latter term being used with the specific applications given above.

*True Degenerations.*—1. Cloudy swelling; 2. hydropic degeneration; 3. fatty degeneration; 4. cholesterin; 5. mucoid degeneration; 6. epithelial hyalin; 7. cornification; 8. pigment degeneration; 9. glycogen.

*Deposits.*—1. Fat; 2. amyloid; 3. connective-tissue hyalin; 4. lime salts; 5. uric acid, urates; 6. cholesterin; 7. glycogen; 8. pigment; 9. exogenous substances.

Within recent years there has developed a tendency to narrow the use of the terms degeneration and deposit, or in some cases (fatty degeneration) to abandon them altogether, and to class the conditions formerly grouped under these terms simply as *disturbances of metabolism*.

The *degenerations* then may be classed as: 1. Disturbances of albumin and fluid metabolism; 2. disturbances of fat metabolism; 3. disturbances of carbohydrate metabolism; 4. disturbances of mineral salts metabolism.

From another standpoint cell degenerations may be classed as: 1. *Morphological* (hypochromatosis, hyperchromatosis, chromatolysis, karyolysis, etc.); 2. *physical* (vacuolar degeneration, cloudy swelling); 3. *chemical* (fat, glycogen, mucin, hyalin, etc.).

TRUE DEGENERATIONS.—*Cloudy Swelling* (Parenchymatous, Granular, or Albuminous Degeneration).—This is the most common form of the true degenerations and is characterized by the splitting up of the cell protoplasm into fluid and albuminous granules. These granules are soluble in acetic acid, insoluble in alkalies and ether, and are not affected by osmic acid. Their presence gives to the cell a cloudy granular appearance: it is swollen and its normal form and structure are lost. In slight degrees of this change the nuclei show but little evidences of disorganization, but in severe cases there are disintegration and loss of staining power of the chromatin. Recovery from the moderate degrees of this degeneration is possible, but after diffusion of the nuclear chromatin the cell undergoes complete destruction, breaking up into a finely granular débris. Most writers believe that cloudy swelling is due less to qualitative changes in the albuminous substances of the cell than to a taking-up of water and a change in the conditions of solubility. Cloudy swelling occurs in the cells of the parenchymatous organs, particularly in the liver and kidneys, in the course of the acute infectious diseases, severe intoxications, etc. It is the chief lesion in the kidneys in the acute degenerative nephritis occurring in scarlatina, septicemia, eclampsia, variola, erysipelas, diphtheria, typhoid fever, etc., and in such intoxications as mercuric chloride, carbolic acid, phosphorus, arsenic, cantharides, etc. To the naked eye the affected organs appear larger, swollen, less shining than normal, and of a grayish color. In severe cases the organ has the appearance of having been cooked, and possesses a color and consistence similar to that of putty. Fatty and hydropic degenerations are often associated with cloudy swelling.

*Hydropic Degeneration.*—In hydropic degeneration there is an increased taking-up of fluid into the cells with a partial liquefaction of the protoplasm, leading to the formation of clear droplets and vacuoles within the cell. Through the confluence of such droplets the entire cell may become changed into a bladder-like vesicle. The nucleus may be similarly affected, being indicated by the presence of a large clear globule consisting of the nuclear membrane distended by fluid. This degeneration occurs most frequently as a precursor to liquefaction necrosis, and is found in blisters of the skin, tumor cells, severe edema, inflammatory processes, etc. It is distinguished from edema in that the staining power of the nucleus is affected, and from liquefaction necrosis in that in the latter the nucleus is entirely lost.

*Fatty Degeneration.*—The conditions formerly called fatty degenerations are now regarded as chiefly of the nature of *degenerative fatty infiltrations*, the fat being brought to the degenerating cells, and not formed, as held by the older pathologists, from the albumin of the cell. In this latter sense there is no true fatty degeneration. We know now that cells in degenerative conditions can take fat out of the blood and lymph, and we have, on the other hand, no proof that fat can arise directly from albumin within the animal body. While it is probable that the chief source of the fat in the fatty degenerations is from without the cell, in the case of some cells the fat may be derived from an intrinsic stable fat that becomes visible as the result of the chemical deconstitution of the cell. In this case the condition is properly styled a degeneration, even if the fat is not derived from the cell albumins. In both cases it is preferable to retain the term fatty degeneration, as the processes

included are distinctly degenerative in character. Cells which are in a state of fatty degeneration contain small, colorless, highly refracting droplets which are soluble in alcohol and ether, insoluble in acetic acid, and stain black with osmic acid. These droplets are very irregular in size and shape, but are usually small except in severe cases, in which they may become confluent, forming larger drops. The parenchymatous organs, liver, kidneys, etc., are chiefly affected, but the degeneration occurs also very frequently in heart muscle, voluntary muscle, connective-tissue cells, and leucocytes. Fatty degeneration occurs in a great variety of pathological conditions: acute infectious diseases such as diphtheria, pneumonia, septicemia, etc.; poisoning by phosphorus, arsenic, chloroform, camphor, etc.; acute anemia resulting from severe hemorrhage; chronic anemia and leukemia; chronic congestion; diminished blood supply caused by sclerosis, thrombosis, etc.; chronic pulmonary tuberculosis, nephritis, chronic alcoholism, etc. In the infectious diseases the degeneration must be attributed primarily to the effects of the poisons produced in these diseases, or to the effects of fever. Prolonged high temperatures lead to extensive fatty degeneration, especially of the heart muscle. Cells out of their normal environment, tumor cells, pus cells, etc., also undergo fatty degeneration. Cloudy swelling and hydropic degeneration are very frequently associated with fatty change. The fat may consist of singly-refractive glycerin-esters or doubly refractive cholesterin-esters. Both may be found in the same cell. The doubly-refractive fat is found especially in the fatty degeneration of atherosclerosis, chronic nephritis, old abscesses, tumor-cells and in the alveolar cells in pneumonia and tuberculosis. Mild grades of fatty degeneration are reparable; in the more severe forms the nucleus and cell-structure suffer and necrosis finally results, the dead cells forming a fatty detritus.

*Cholesterin.*—This occurs as a pathological degeneration in tissues and exudates which are in process of fatty degeneration or necrosis. Its source is not clearly understood, but it is probably a product of the splitting up of lipoid substances. There appears to be a close relation between the formation of cholesterin and the occurrence of doubly-refractive fat-droplets. It occurs in the form of thin, rhombic plates having usually a notched corner, in atheromata, fatty degeneration of sclerotic vessels, old extravasations, old echinococcus cysts, dermoid cysts, cholesteatomata, necrosing adenomata of the thyroid, and purulent exudates. Besides showing a characteristic form cholesterin crystals show a color-reaction with iodine and concentrated sulphuric acid, the edges of the crystals becoming red, violet, and blue. In material imbedded in paraffin the cholesterin crystals are dissolved out during the process and leave the characteristic spaces called "cholesterin-clefts." Not infrequently these clefts are surrounded by foreign-body giant cells.

*Mucoid Degeneration.*—The pathological formation of a stringy, gelatinous fluid from epithelial cells or connective tissues is known as mucoid or myxomatous degeneration. This change has a physiological prototype in the formation of mucus in mucous membranes and glands, and in the umbilical cord, tendons, bursæ, and synovial membranes. In mucous membranes the production of mucus takes place in goblet cells. These are swollen epithelial cells whose protoplasm has become altered into a clear substance containing small granules or strings. In mucous degeneration of epithelium the number of goblet cells becomes greatly increased (catarrhal inflammation). Pus cells, the epithelium of cystadenomata, and carcinoma cells very frequently undergo mucoid change. In mesoblastic structures the intercellular substance undergoes a mucous change, becoming altered into a gelatinous mass. The cells of the tissue may also be converted into mucus. This change occurs in fibrous connective tissue, cartilage, bone, bone marrow, and fat, and especially in the case of the mature connective-tissue tumors and the sarcomata. In severe cases the entire tissue may become changed into a clear, translucent mass. The chemical nature of mucus varies greatly in different cases, and at present but little is known of its real composition. Its chief constituents are known as mucin and pseudomucin, and several varieties of these are described, so that it is probable that they do not represent single chemical substances. Mucin is precipitated by acetic acid while pseudomucin is not. Mucin, in tissues that have been fixed, stains deep blue with mucihematin, and red with thionin, kresyl-violet, or mucicarmin. From both mucin and pseudomucin a carbohydrate may be formed, from which fact one is justified in classifying them as glycoproteins. Pseudomucin is found especially in the cystadenomata of the ovary and is the product of the epithelial cells lining the cysts. It is found also in mucous carcinomata.

*Epithelial Hyalin or Colloid.*—Under this head may be grouped all of the substances that arise from the degeneration of epithelial cells and that have a structure like that of the colloid of the thyroid. These substances are, however, very different in origin and chemical nature and cannot be regarded as being identical in kind. They resemble each other in that they are all transparent, homogeneous, albuminous substances that do not stain red with Van Gieson's stain as does connective-tissue hyalin. In contrast to mucin epithelial hyalin is not affected by alcohol or acetic acid, but remains homogeneous. Epithelial hyalin or colloid is found normally in the thyroid, hypophysis, and prostate. That of the thyroid and hypophysis is characterized by its iodine content. It occurs in greatly increased amount in colloid goiter. Metastases of thyroid tumors may also contain colloid.

Those pathological substances found in various portions of the body which bear a close resemblance to the colloid of the thyroid, and which like it are the products of epithelial cells, may be classed as colloid-like bodies. The chemical composition of these bodies cannot be identical; their grouping together into one class is based upon general resemblances only. They represent transformed products of epithelium, and in common are hyaline, gelatinous substances which do not stain like mucin. Such bodies occur pathologically in the kidney tubules (casts), ovarian and parovarian cysts, retention cysts in mammary glands, parotid, skin glands, pancreas, kidneys, endometrium, etc. Similar substances are found also in the prostate, hypophysis, central nervous system, lungs, etc. They occur partly in the shape of homogeneous hyaline bodies and partly in the form of laminated concretions (corpora amylacea). Since in the majority of cases these bodies are found in gland spaces, they must be regarded as a modified epithelial product which is formed under conditions very different from those attending the deposit of amyloid, and though occasionally giving a similar reaction with iodine cannot be considered as being identical. The colloid-like bodies found in the nervous system are derived either from degenerating neuroglia cells or from fragments of axis cylinders. The hyaline inclusions of carcinoma cells may also be classed as a form of epithelial-hyalin degeneration.

*Cornification.*—Pathological cornification occurs in a great variety of conditions. Hyperplasia of the horny layer of the entire skin may occur (ichthyosis, lichen pilaris, etc.), or local thickening may take place (ichthyotic warts, callosities, corns, etc.). These changes may be included under the general term of hyperkeratosis. Pathological cornification also occurs in regions of the body where normally it does not take place at all or but to a very slight

degree. The ducts of the skin glands may be so affected; cornification may also occur in the mucous membrane of the mouth, middle ear, uterus, vagina, urinary passages, in the mastoid cells, etc. Further, keratohyalin is formed in tumors of the skin, meninges, brain, etc. (squamous-celled horny cancer, dermoids, cholesteatomata). In all of these conditions the process is a true cell degeneration, the keratin being formed by the cells at the expense of their nuclei. As the keratohyalin granules are formed and escape from the cells there is at the same time a shrinking of the nuclei, leading ultimately to their disappearance.

*Autogenous Pigments.*—The pigments which are formed by cell activity—melanin, hemofuscin, and lipochrome—may all be produced in excessive amounts under certain pathological conditions. This increase of pigment manufacture is analogous to the increased production of mucus, colloid, etc.; and for this reason it may be classed with the true degenerations. An excessive formation of melanin occurs in local melanosis of the skin (pigmented moles, sun-burn, etc.); in general melanosis, in Addison's disease, and in severe cachexias. Melanin degeneration occurs also in the cells of melanotic sarcomata. In these, death of the cell usually follows the formation of the pigment. Hemofuscin is produced in excessive amount in the atrophy of heart and unstriped muscle. Lipochrome is formed to such an extent in certain forms of sarcoma as to give them a green color (chloroma).

*Glycogen.*—Glycogen occurs in the tissues in a manner analogous to fat, both as a labile and a stable glycogen. An increase in the latter associated with degenerative changes in the cells may be interpreted as a degenerative glycogen infiltration or a glycogen degeneration. The glycogen content of a cell represents a phase in the carbohydrate metabolism; it may represent in one case an increase in metabolic activity, in another a decrease, in a third case it may be an infiltration or resorption phenomenon, while in a fourth it indicates a degenerative process. Such a glycogen degeneration may be found in tumor cells, leucocytes, endothelium, epithelium, etc. The diagnosis of glycogen degeneration must be made with the same points of view as that of fatty degeneration.

Deposits.—*Fat.*—A pathological deposit of fat may take place in tissues where fat is found normally or in those in which it is not a normal constituent. The cells that take up the fat are otherwise apparently normal; the fat comes from outside the cells, and is taken up by the latter as such or in the form of its components. Both singly refractive and doubly refractive fats (glycerin-esters and cholesterin-esters) may be deposited as a *simple fatty infiltration.* In excessive accumulation of fat the subcutaneous and subserous adipose tissue, bone marrow, and liver are first affected; later, the intermuscular connective tissue of the heart and voluntary muscles, endocardium, etc., may become the seat of deposit. The fat is deposited in the shape of small droplets which become confluent into larger drops, so that ultimately the entire cell body may be replaced by it and converted into a globular mass of fat. Fatty infiltration occurs in general obesity, congenital and acquired; in chronic anemia and cachexia; in chronic alcoholism, etc. The causes of pathological accumulations of fat are: increase in the fat-storing metabolism, inability on the part of the body to break down the fat received into it or already stored there, deficient oxygenation of the blood and tissues, chemical substances reducing the metabolic activity of the cells, etc. A simple fatty infiltration occurs as a compensatory process secondary to atrophy or necrosis of certain organs, or following the normal involution of certain tissues (fatty infiltration about the atrophic kidney, fatty atrophy of pancreas, heart and striped muscle, fatty involution of thymus and lymph-nodes).

*Amyloid.*—The terms amyloid and lardaceous degeneration have been applied to the deposit of a hyaline, homogeneous, wax-like substance in the walls of the smaller blood-vessels. It may occur in almost every part of the body, but is most commonly found in the spleen, kidneys, and liver; less frequently in the intestine, stomach, lymph glands, pancreas, adrenals; and rarely in the muscles, ovaries, uterus, respiratory tract, etc. As a result of an extensive deposit of amyloid the affected organs become enlarged, translucent, waxy and more resistant. The amyloid substance gives a reaction with iodine somewhat resembling that of starch, and for this reason it was once regarded as a body closely related to cellulose or starch; hence its name amyloid. Later, its nitrogenous nature was discovered, and it is supposed to be a coagulated albuminous body intermediate between the proteins on the one hand and fat and cholesterin on the other. The exact chemical nature of amyloid has not yet been determined. Many writers regard it as a compound of a basic albuminous body and chondroitin-sulphuric acid, but this is denied by others. It is very resistant to the action of chemicals and the agents of putrefaction. With certain of the aniline dyes amyloid exhibits a metachromatic reaction. Amyloid is never deposited in living cells, but is found in the interstices of the connective tissue in or near the walls of the smaller blood-vessels. In the early stages of the deposit it lies always just outside of the endothelium. It is therefore probable that it is formed by the secreting cells of the vessel walls and deposited in the lymph spaces in and near the vessels. It occurs most frequently in the various cachexias, especially in pulmonary tuberculosis, chronic suppuration, syphilis, chronic dysentery, leukemia, etc.

*Connective-tissue Hyalin.*—Closely related to amyloid in its general appearances and mode of formation is the homogeneous deposit found in the walls of blood-vessels and in the interstices of connective tissue which is known as hyalin. It differs from amyloid chiefly in that it does not give the characteristic reactions of the latter. That there exists a very close relationship between the two substances is shown by the fact that amyloid organs often contain hyaline areas which do not give the amyloid reactions, and that pieces of amyloid when introduced into the peritoneal cavity of animals lose their characteristic reactions. In further contradistinction hyalin stains a deep red with Van Gieson's method, while amyloid stains a pinkish-yellow or brown. It is differentiated from epithelial hyalin by the same staining reaction. Hyaline deposit is found chiefly in the walls of blood-vessels (sclerosis), endocardium, connective tissue of the thyroid, lymph glands, ovaries, glomeruli of the kidneys, and in the connective tissue of many forms of tumors. In the connective tissue of certain organs, especially in that of the conjunctiva, hyalin appears to be more of the nature of a degeneration than of a deposit. The connective-tissue cells may undergo a change into a hyaline substance containing no nuclei, or the hyaline formation may owe its origin to a secretory activity on the part of the connective-tissue cells. Conjunctival hyalin appears to be formed in this way. In other cases hyalin partakes both of the nature of a degeneration and of that of a deposit, the connective-tissue spaces being first filled with a clear, homogeneous substance into which the cells are gradually fused, the whole ultimately becoming converted into hyalin. As in the case of epithelial hyalin the various forms of connective-tissue hyalin present no chemical unity, but represent a series of albuminous modifications having the optical properties of amyloid but not the staining reactions of the latter. The small hyaline granules (fuchsinophile bodies) found in connective tissue are also included by some writers under the head of hyalin. They are partly the results of cell degeneration (plasma cells) and partly derived from inflammatory

exudates. The deposit of hyalin occurs under conditions similar to those in which amyloid develops: it is found in old age, syphilis, various cachexias, chronic inflammations, etc. All scar tissue ultimately becomes hyaline (hyaline tubercles, glomerular scars, etc.).

*Calcification.*—The deposit of lime salts in the body tissues is of very frequent occurrence. Such deposits may consist either of granular and amorphous masses or of crystals. They may occur in the tissues which form a normal part of the structure of the body, or an incrustation may be deposited around tissues which have been separated from their normal surroundings; or foreign substances which have entered the body may become the center of deposit. In the first case the process is spoken of as calcification of tissue; in the latter as the formation of concretions and calculi. Calcification never takes place in perfectly normal tissue. It is usually preceded by some degenerative change: cloudy swelling, fatty degeneration, hyaline change, necrosis, etc. In the human body a visible deposit of lime salts outside of bone is to be regarded as a sign of severe disturbances of metabolism and the death of the cells involved. Dying tissue which has undergone more or less change appears to possess a certain attraction for the lime salts held in solution within the body and to cause their precipitation. Connective tissue which has undergone hyaline change is especially likely to become calcified. Tissues possessing an especial affinity for lime salts usually show an increased affinity for iron. Calcification occurs also in areas of caseation in any part of the body, in tissues showing fatty degeneration or beginning necrosis, as in the renal epithelium in cases of poisoning by mercuric chloride, aloin, and bismuth. In fat necrosis due to the action of a fat-splitting ferment the free fatty acids may combine with lime salts ("fat stones"). In old age extensive calcification may occur in tissues which show but little change. This takes place to the greatest extent in cases showing marked osteoporosis. The lime salts removed from the bones are deposited in the capillary walls in the lung, kidneys, and mucosa of the stomach, as well as in the intima of the smaller cerebral vessels. Concretions of lime salts are met with in the meninges, caseating areas, psammomata, nodular growths in connective tissues, organizing thrombi, etc. Calculi composed partly or wholly of lime salts may be found under varying conditions in all of the ducts and cavities of the body (salivary, bronchial, urinary, biliary, prostatic, and other calculi). All of these possess an organic basis around which the deposit has taken place. The calcium salts found in the body are either the phosphates, the carbonate, or the oxalate. Magnesium salts are not infrequently found in combination with these. Other substances such as uric acid, bile pigment, etc., are also found mixed with lime salts in various forms of calculi.

*Uric Acid, Urates.*—A deposit of uric-acid salts takes place in gout, chiefly in the form of sodium urate, with which small quantities of calcium phosphate and carbonate are combined. These deposits occur in the kidneys, skin, subcutaneous tissues, tendon sheaths, tendons, ligaments, synovial membranes, and articular cartilages. The great toe is a favorite seat of deposit. In marked cases every organ in the body may be affected. Fine acicular crystals of sodium urate are found in the tissues, which show at the seat of deposit a more or less advanced necrosis. The larger deposits about the joints are called tophi. Uric acid and urates are found in the kidney tubules in the condition known as uric-acid infarct, which is of rather frequent occurrence in the new-born. Calculi of the same substances are found frequently in the tubules and pelvis of the kidney, the ureters, and in the bladder. Pure uric-acid calculi are small, hard, and reddish in color. Calculi of urates are usually partly composed of lime salts.

*Cholesterin, Cystin, etc.*—Cholesterin is found as a deposit in gallstones. These may consist of pure cholesterin or be combined with bile pigment, lime salts, etc. Cystin calculi are found in rare conditions when cystin is excreted by the kidneys as the result of peculiar metamorphoses of albumin produced in the intestine through the action of bacteria. Cystin calculi are yellowish, soft, and waxy. Calculi composed of xanthin are found rarely in the bladder. They are red in color, and of a soft, friable consistence.

*Glycogen.*—As the result of disturbances in the carbohydrate metabolism cells that normally contain glycogen may obtain an excessive amount through excessive production or lessened use, or through increased resorption. A pathological glycogen infiltration may occur, therefore, as the result of widely varying courses. In diabetes excessive amounts of glycogen are conveyed by the blood to certain organs where it is deposited in the parenchymatous cells. This takes place to the most marked extent in the kidneys where the glycogen is deposited in the epithelium of Henle's loops, especially in the isthmus of these where the cells are almost entirely filled with it. It appears in the cells in the form of hyaline droplets which are usually collected near the nuclei. After the glycogen has been dissolved out by water clear vacuoles are left in the cell.

*Pigment.*—Melanin may occur as a deposit in various organs, especially in the spleen, lymph glands, and kidney, in the case of necrosing melanotic sarcomata in which the pigment is either set free in the blood or lymph or carried there by leucocytes. It may also appear in the urine, and casts of melanin may be found in the renal tubules. An exogenous ochronosus may be produced by the absorption of minute quantities of carbolic acid through long periods of time, fermentative pigments being split off from the latter. In icterus the bile pigment may be deposited in all of the tissues and organs of the body, giving to them a yellow or greenish color. Hematogenous pigments, hematoidin and hemosiderin, are found in the tissues as remains of hemorrhages. The pigment granules may be taken up by leucocytes and carried to the spleen, lymph glands, bone marrow, etc., being deposited in these organs in the shape of yellow or brown granules which may be so numerous as to impart a distinct color to the part. In many of the acute infectious diseases, malaria, pernicious anemia, leukemia, various forms of poisoning, etc., large numbers of red blood corpuscles may be broken down and an increased amount of blood pigment be carried to the spleen, liver, kidneys, etc. This may be compensated for by an increased activity on the part of the liver in the formation of bile, but if the amount of hemoglobin is too great to be disposed of in this way pigment may be deposited in the liver cells and in other organs and tissues. Such organs become yellow or brown if the deposit is at all marked, and to this condition the term hemochromatosis has been applied. Since hemosiderin is the pigment most commonly found it is proper to speak of the pigmentation as a hemosiderosis. In the liver cells hematoidin is usually deposited in the central zone of the lobule, while hemosiderin is found in the periphery of the lobule. In the kidneys the pigment is deposited chiefly in the cells of the convoluted tubules; in the spleen, lymph glands, and bone marrow it is contained chiefly within the endothelial cells lining the blood spaces. Through the absorption of hydrogen sulphide from the intestine, organs containing hemosiderin in excess may become black in color (pseudomelanosis). In addition to the hematogenous pigments formed in malaria through the destruction of the red blood cells, the pigment formed by the plasmodia themselves may collect in the smaller arterioles and capillaries. It is black, contains no iron, and its exact chemical nature is unknown.

*Exogenous Substances.*—Foreign substances may be

introduced into the body from without and be deposited in the tissues. The variety of such substances is very great and their mode of entrance into the body is also greatly varied. Insoluble substances may be introduced through open wounds of the skin (tattooing, trauma). The lungs are the most frequent point of entrance: through them coal dust, stone and iron dust, soot, etc., enter and are deposited in the lung tissues and in the bronchial lymph glands. Under certain conditions (tuberculous caseation, etc.) these substances may get into the general circulation and be deposited in the liver, spleen, bone marrow, etc. Soluble metallic salts, such as those of silver and lead, may be taken in through the stomach and intestine, and deposited in certain organs and tissues in an insoluble form.

The causes leading to the pathological degenerations and deposits may be either intrinsic or extrinsic. The former may be inherited or it may arise by primary germ variation. For the greater part both degenerations and deposits are produced by injurious extrinsic influences to which the body is exposed during life. Disturbances of nutrition, deficient oxygenation, circulatory disturbances, intoxications, infections, etc., play the chief part in their production, but any external force which may injure the body may lead likewise to pathological alterations of its organs or tissues which may assume either the form of a degeneration or that of a deposit. These changes may be of limited extent or the entire organism may suffer as the result of general disturbances of nutrition. Deposits may be followed by secondary retrograde changes, such as atrophy, fatty degeneration, etc., as the result of presssure or diminished blood supply. No general statements can be made regarding the course and symptomatology of the degenerations and deposits, as these vary within the widest limits according to their etiology and association with other pathological conditions. (See also *Amyloid, Colloid, Concretions,* etc.)

ALDRED SCOTT WARTHIN.

**Deglutition.**—Deglutition is the physiological act or process by which food is conveyed to the stomach. There are two principal theories in regard to its mechanism, one based upon the description of Magendie, the other upon the investigations of Kronecker and Meltzer.

Following Magendie, it is customary to describe the act of swallowing as occurring in three stages, each representing the passage of the food through one of the three anatomical regions involved, namely, the mouth, the pharynx, and the esophagus. After the food has been masticated and collected into a bolus, the mouth is closed and the jaws are brought together. Deglutition then begins with the elevation of the tongue against the palate, its tip, middle, and base pressing upward in succession, through the action of its intrinsic muscles and the styloglossus. The bolus is thus forced backward through the isthmus of the fauces into the pharynx. During its passage the soft palate is elevated by the contraction of the levator palati muscles and is made tense by the tensor palati; the pillars are made straight and tense through the action of the palatopharyngeus, which also assists in the closure of the posterior nares. There is at the same time a slight protrusion forward of the posterior wall of the pharynx through the contraction of the salpingopharyngeus, and the uvula is elevated by the azygos uvulæ to complete the closure of the passage into the posterior nares.

This, the first stage, is regarded as voluntary in character; but it is not fully under control of the will, for in the absence of a moist bolus or of fluid to be swallowed the act becomes difficult and cannot be repeated indefinitely; the presence of dry food or of a dry powder on the tongue exerts an inhibitory influence.

The second stage consists in the passage of the food through the pharynx, which is accomplished by a number of rapid muscular movements. The contraction of the stylopharyngeus and palatopharyngeus muscles raises the pharynx like a funnel and tends to draw it over the descending bolus, which is now seized and carried rapidly downward by the constrictors of the pharynx. The approximation of the anterior pillars of the fauces through the action of the palatoglossi prevents its regurgitation. The other muscular movements which accompany these have for their object the closure of the glottis. This is accomplished by the elevation of the thyroid cartilages behind the hyoid bone through the action of the laryngeal muscles; the approximation of the arytenoid cartilages and the vocal cords by the lateral cricoarytenoids and the constrictors of the glottis; and the depression of the epiglottis, which is sometimes accomplished, perhaps, in a purely mechanical way, but is normally brought about by the concerted action of the thyrohyoids, digastrics, geniohyoids, mylohyoids, and the fibers in the arytenoepiglottic folds.

The third stage is a much slower movement, requiring six seconds for its completion. The food enters the esophagus with great rapidity and continues to move rapidly through its upper third, the part supplied with striated muscle fibers. Through the lower two-thirds the movement is slower, depending solely upon the involuntary musculature.

The Kronecker-Meltzer theory attributes the most important part in deglutition to the contraction of the mylohyoid muscle and is based upon carefully conducted experiments. After the bolus of food has been collected on the dorsum of the tongue and its passage forward has been prevented by the elevation of the tip against the palate, these muscles contract with force and put so great pressure upon the bolus that it is shot through the pharynx into the esophagus, the action being assisted by the simultaneous contraction of the hypoglossi which draw the tongue backward and downward and thus increase the pressure. This action also serves to depress the epiglottis and to protect the larynx. Soft or liquid food passes rapidly through the esophagus to the cardiac orifice of the stomach, the time required for its descent being not more than one-tenth of a second. The peristaltic wave of the esophagus is regarded as a reserve movement intended for the removal of such fragments as lodge in descent or for the completion of deglutition when the bolus is not of a proper character for rapid descent. It is needed, however, in many individuals to force the food through the cardiac constriction. Six seconds are required for the completion of the act in this manner. The esophagus contracts in three successive segments. The first is about six centimeters long and is the neck portion, the part endowed with striated muscle. It begins to contract in about one or one and two-tenths seconds after the beginning of deglutition and requires two seconds for its completion. The second segment, the upper thoracic portion, is about ten centimeters in length; its contraction begins about one and eight-tenths seconds after the first segment begins to contract and lasts for from six to seven seconds. The remaining third portion begins to contract about three seconds later than the second and continues for from nine to ten seconds. The act of deglutition is thus divided into five instead of three stages, corresponding to the contraction of the mylohyoids, the constrictors of the pharynx, and the three esophageal segments. A single act of swallowing requires six seconds for its completion, as stated; but if the act be repeated within this time, the peristaltic wave is arrested and the bolus is carried to the stomach by a subsequent wave which is completed six seconds after the beginning of the last deglutition.

*Nervous Control.*—Deglutition is a reflex act. A certain stimulus, as that of food or drink or a few drops of saliva, seems to be required for the perfect

accomplishment of even the first stage, the most voluntary part of it. The afferent impulse is conveyed, presumably from the mucous membrane of the mouth or pharynx, to the deglutition center by the glossopharyngeal, trifacial, and pneumogastric through the internal branch of its superior laryngeal division. No deglutition center has been definitely located, but it is supposed to lie near the anterior surface of the medulla. It probably comprises parts of the nuclei of origin of the nerves employed in the act of swallowing, namely, the hypoglossal, facial, trifacial, glossopharyngeal, and pneumogastric, and is not an individual collection of cells.

Mosso found that when an entire segment of the esophagus is removed the contraction of the part below the injury takes place in its natural order as though the tube were intact. Kronecker and Meltzer observed the same action after ligature or division. This is made possible by the manner in which the tube is innervated by branches of the pneumogastric and sympathetic. These form a plexus between the muscular coats in which are groups of ganglion cells and another in the submucous layer. Although the part taken by each of these cannot be exactly described, the impulses are conveyed through them in such a manner that the wave of contraction travels downward from the upper portions to the lower regardless of the integrity of the tube.

Recently Mr. Horace Fletcher, in advocating excessive mastication, has asserted that there is a rudimentary pharyngeal reflex in certain subjects which prevents the swallowing of formed morsels of food and cites medical and personal authority in regard to the presence of such a reflex. In other words certain subjects, he claims, cannot swallow food until it has been reduced to a mere emulsion.

James M. French.
Edward Preble.

**Deiters, Otto Friedrich Karl.**—Born at Bonn, Germany, November 15, 1834. He received the degree of Doctor of Medicine in 1856. After he had settled in Bonn, in 1858, he soon became actively employed in microscopical and clinical researches. His discoveries in regard to the finer structures of the labyrinth of the organ of hearing soon made him quite famous. His death from typhoid fever occurred on December 5, 1863.

Of his published writings the following deserve to receive special mention: "Untersuchungen über die Schnecke der Vögel," in Reichert's and Dubois, Archiv, 1860; "Ueber die Lamina spiralis der Schnecke," in Zeitschrift für wissensch. Zoologie, X.; "Untersuchungen über die Lamina spiralis membranacea, etc.," Bonn, 1860; and "Ueber das innere Gehörorgan der Amphibien," Reichert's and Dubois' Archiv, 1862. A. H. B.

**Delirium.**—(Latin, *Delirium*, madness.) When the action of the different parts of the brain is fully coördinated, we have a feeling of awareness of what is going on and this feeling we call consciousness. Let the coordination be disturbed and consciousness is impaired or lost. By delirium is understood a clouding of consciousness more or less profound, with hallucinations and illusions, and with or without motor unrest.* As to the exact method of its production, further than that it depends upon causes which interfere with the harmonizing of the influences coming from the different neurones of the central nervous system, we have no exact information. It is not in itself a disease, but a symptom-complex which may occur in connection with a number of conditions and while it is in strictness a form of mental aberration, differing mainly in its immediate cause and in its course from other insanities, on account of its common association with systemic disease and its tendency to disappear with the improvement of the underlying condition, it comes most usually under the care of the general practitioner. Delirium occurs as an incident in so many morbid conditions and while the clinical picture may vary somewhat, its general characters are so similar withal, that to describe each kind of delirium would be superfluous, hence it will suffice to mention briefly its exciting causes and to outline its chief symptoms, emphasizing the features which characterize delirium from different sources.

Delirium may complicate:

1. Organic diseases of the brain, as meningitis and encephalitis, vascular disease, cerebral hemorrhage, embolism and thrombosis, abscess, tumors, general paresis, and other forms of insanity of less definite pathology.

2. Infectious diseases, particularly typhus and typhoid fevers, with the other eruptive fevers, acute rheumatism, pneumonia, syphilis, diphtheria, rabies, etc.

3. Intoxications: (*a*) From endogenous poisons as those produced in nephritis (uremia), diabetes, and hepatic insufficiency, and the poisons arising in the digestive tract (intestinal autointoxication); (*b*) from exogenous poisons as alcohol, ether, chloroform, illuminating gas (CO), opium, belladonna, hyoscyamus, salicylic-acid preparations, digitalis, ergot, lead, mercury, etc.

4. Inanition and exhaustion (collapse delirium).

5. The psychoneuroses of uncertain origin as epilepsy and hysteria. These causes may readily overlap, for infectious diseases may set up organic changes in the brain and the toxins produced by their exciting agents may paralyze certain neurones, irritate others, or may make them more susceptible to alcohol or other drugs administered for therapeutic purposes, while in the later stages, the factors of inanition and exhaustion come in. In epilepsy there may be organic disease of the brain though the changes may be so fine as to escape recognition by our present means of investigation, while the fits which the delirium either precedes or follows, or for which it is substituted, are often set off by some toxic influence, particularly by alcohol and by the poisons of the digestive tract. When there is underlying hysteria, almost any kind of a shock or strong suggestive influence may set off the delirious episode. The so-called traumatic delirium may be of hysterical character or may have a composite origin in operative cases in the shock, loss of blood, the anesthetic, and even in the injudicious use of strong antiseptics as corrosive sublimate or iodoform. Each case of delirium must be studied as to all possible etiological factors.

In organic disease of the brain, free interplay between neurone and neurone may be interfered with, either by destruction of cells or by severing of association fibers, so that coordination of impressions on the one hand, and inhibition of influences upon the other, may be imperfect or lacking, so there is mental dissociation more or less marked, while at the same time irritation of neurones still intact may be set up. Hence the clouding of consciousness, the fallacious perceptions, the irritability, and the motor impulsions of the delirious state. The neurones may also be injured by the high temperature and by circulating toxins in infectious diseases, and by the poisons in the intoxications.* In inanition there is altered metabolism, probably with the production of poisons

* By French authors, the term delirium (délire) is used to describe, not only acute conditions, but also more chronic states characterized by delusions, more or less systematized.

* Guillain and Laroche have recently published some very interesting experiments illustrating the affinity of toxins and other poisons for nervous tissues and the extent to which they are capable of fixing themselves in the central nervous system. (*La Semaine Médicale*, No. 29, 1911.)

(acetone appears in the urine), while in collapse the blood distribution is so altered as to inadequately and irregularly nourish the brain neurones. The circulation in fact may be disturbed in all the above-mentioned conditions. In organic disease, however, the change is permanent, while, the other causes ceasing to act, there is restoration of function. A certain nervous instability, hereditary or acquired, seems, however, an important predisposing factor in delirium, for the action of the causes mentioned above is not always sufficient to set it up. The degree of clouding of consciousness is not always proportional to the height of the temperature, or to the intensity of the intoxication—some persons become delirious with only slight fever or infection, while others preserve mental clearness throughout the gravest attacks. Especially in children does the mobile nervous system respond to febrile attacks with delirium. A predisposition is readily acquired by the habitual use of drugs, especially alcohol. Pneumonia in alcoholics is nearly always accompanied by delirium, especially when the apex of the lung is involved.

Delirium occurring in infectious diseases is so striking and typical that its description may well serve to illustrate the clinical features of this symptom-complex. It may occur during the period of invasion, at the height of the disease, or during defervescence. It is observed most frequently in typhoid fever. In the preliminary stages the patient is irritable and depressed, he suffers from headache, difficulty in collecting his thoughts, and incapacity for mental effort. His sensorium is more or less dull, when he falls asleep he is disturbed by dreams, often disagreeable or terrifying, and he may wake in a fright and be a little confused for a time. These dreams have a certain importance in that they sometimes serve as a starting-point for later delusional ideas (oniric delirium). As the temperature goes higher and the toxemia becomes more marked, consciousness is more and more clouded, though the mind continues to act in labored and troubled fashion. The patient has hallucinations and the persons and objects around him are the subjects of illusional interpretation. He may trouble himself greatly about the pattern of wall paper, in which he traces shapes or faces, articles of furniture are mistaken for animals, etc. The noises of house and street are interpreted as the cries of a mob, there is fire and his dear ones are being burned up, a battle is going on, he sees the wounded and heaps of the slain, hears the shots, the cries and groans, etc. He is threatened, pursued, will be killed, his wife or daughter is being assaulted, so he attempts to flee from the room or to rush to the rescue and if not restrained, may leap from the window. On the other hand he may hear sweet music and have beatific visions. Depending upon the amount of cerebral irritation and the character and vividity of his hallucinations the delirium may be quiet or violent. In the latter (furibund delirium) the patient is in constant agitation, sings, shouts, makes muscular efforts, and would jump from the bed if permitted. Periods of violence may alternate with intervals in which the patient lies quiet, covered with sweat from his exertions, perhaps in a strained attitude. He groans occasionally and muscular tremors pass over his body. As the disease approaches its height and the exhaustion of the patient becomes more extreme, he is quieter, lies with open eyes, muttering to himself and picking at the bed clothes. There are muscular twitchings, the tongue is coated, the breath foul, and the patient presents the picture of severe illness; in unfavorable cases, the clouding of consciousness deepening to coma, and death ensuing.

In favorable cases, with abatement of the fever the patient becomes quiet and his mental condition gradually clears up. In some instances, however, clouding of consciousness persists in spite of the fall of the temperature and the condition passes over into a postfebrile psychosis. On the other hand, the patient may have passed through the fever, with little or no delirium. When in the stage of defervescence there develops a dreamy confusional condition with numerous hallucinations and illusions and motor impulsions or unrest (postfebrile, collapse, or inanition delirium). While the symptoms of collapse delirium are very various, throughout the whole runs the train of anxious confusion, mental and motor irritability, and tremulous weakness. The hallucinations and illusions are of the most varied character and may affect any of the senses. They may be the starting-point for delusional interpretations, which on account of his mental weakness the patient is unable to correct, and a certain systematization of the delusions may be observed. The patients have a feeling that everything has been changed, that they are not "right in the head." They are emotional, show extreme variability of mood from depression to exaltation, and sometimes flight of ideas with a tendency to association by sound. There may be muscular twitchings, or again stereotypy, negativism, and other katatonic symptoms which may suggest dementia precox, while in some cases there are ataxia and speech disturbances which might suggest general paresis. Postfebrile delirium has a somewhat prolonged course and may last three or four months, though its prognosis is in general good. It differs clinically, little if at all from psychoses arising upon the basis of inanition or exhaustion from other causes, and shades off into the hallucinatory-confusional conditions described under the names of acute confusion, amentia, "wahnsinn," and acute paranoia, though in the last mentioned there is a certain systematization of delusions, which imparts a paranoid character to the case. The symptomatology of delirium as occurring in the infectious diseases is in general that presented above, and while there may be variations in different diseases, they are not sufficiently characteristic, or constant enough, to justify the division of deliria into special forms, as typhoid, pneumonic, or septic delirium.

That delirium depends not only upon the fever but also upon the toxins in infectious disease is shown by its occurrence in cases of infection, with little or no elevation of temperature as in sepsis, between the febrile paroxysms in malaria, etc. Not only do we encounter marked delirium in nephritis, especially when the circulation has begun to break down, in diabetes, and in diseases of the liver, but in many cases of hallucinatory confusional psychoses there is evidence of severe disturbance of the digestive functions, with the increase of indican and the ethereal sulphates in the urine, which would seem to justify the idea that they are due to intoxication by poisons arising from the digestive tract. This is also possible in inanition delirium. While delirium has been observed in poisoning, both acute and chronic, by a great number of drugs, as cocaine, opium, belladonna, cannabis indica, digitalis, ergot, etc., as well as from metals and from poisonous gases, the toxic delirium *par excellence* is observed in chronic alcoholism (*q.v.*).

*Delirium Tremens.*—With the restlessness, confusion, and hallucinations of delirium in general, there is the characteristic tremor which gives the name of "delirium tremens" to acute alcoholic delirium. Delirium tremens occurs almost exclusively in habitual drinkers, and especially in those who indulge in the stronger alcoholic beverages. It may be precipitated by an injury of some kind and is a specially frequent accompaniment of pneumonia in an alcoholic. Beginning very much as described for delirium in general, it is characterized at its height, by visual hallucinations, generally terrifying but sometimes ludicrous; the patient sees faces which grin at him, or shapes that threaten, small animals which crawl over him or over the bed. He is disoriented as to

place, thinks himself at his store or shop, or engaged in his usual occupation, or, on the other hand, he is threatened or pursued and terrified, attempts to flee or assaults those about him. He may show intense anxiety, trembles, and is covered with sweat, or, on the other hand, while he has hallucinations, they do not frighten, but rather amuse him. The hallucinations can sometimes be brought out by pressure over the eyeballs, or by having the patient gaze fixedly at a wall or at a piece of blank paper, asking him from time to time what he sees. Auditory hallucinations are rare in contradistinction to the more chronic alcohol hallucinosis. The patient presents the signs of chronic alcoholism, and suffers from insomnia and from irritability of the stomach. The delirium terminates as a rule in from three to ten days in a critical sleep though from ten to fifteen per cent. of the cases die, mainly those who have been through several attacks.

*Delirium Acutum.*—Under the name of acute delirium (acute delirious mania, typhomania) is described a class of cases which, beginning either as delirium or with manic excitement, under rising temperature, pass into a condition of restlessness and excitement with flight of ideas and eventually with extreme incoherence and constant motor agitation. The patient screams or roars, is constantly in motion until he sinks into a state of exhaustion. His body is covered with sweat, frequently bruised from contusions incident to his constant struggling. His tongue is coated, his breath foul, and he presents the picture of grave illness. The temperature is elevated, frequently hyperpyretic toward the end and in cases which last long enough; emaciation and prostration are extreme.

The prognosis is exceedingly grave, the outcome being fatal in a large proportion of the cases. Acute delirium is not regarded as a definite disease, but occurs under a number of conditions. In some instances it appears to be a hyperacute mania, in others a galloping form of general paresis, while in still others it is a symptom of grave somatic disease or severe infection. In epilepsy, delirium may occur in connection with a convulsive seizure, or may be substituted for it. The hallucinations are vivid and terrifying, or on the other hand beatific, and mental dissociation is very great, the patient often carrying out the most complicated acts of which he later has no recollection. He may be guilty of extreme and fatal violence during this period. As a rule, however, the characteristic epileptic mental disturbance is more of a dreamy confusional state than an active delirium. In hysteria, delirious conditions occur most frequently as temporary episodes, though they may be prolonged. They are usually set up by some strong psychic influence and are accompanied by some of the well-known stigmata of hysteria.

*Pathological Anatomy.*—Since delirium is a symptom-complex appearing as a complication in a number of diseases, it could hardly be expected that it would present a definite and unique pathological anatomy. Nevertheless, in fatal cases changes have been found in the brain, complicated or not with changes in other organs, depending upon the underlying disease. The most definite alterations in the brain have been found in those cases which having run the stormy course of delirium acutum have terminated fatally by exhaustion. While these changes can hardly be said to be characteristic, the postmortem findings are described as being in general:

Macroscopic.—Hyperemia of the pia mater and cortex.

Microscopic.—Microorganisms of different kinds (pneumococcus, diplococcus, etc.) cell alterations, as cloudy swelling and chromatolysis more or less extensive, slight diminution in the number of medullated nerve fibers in the cortex, proliferation of the neuroglia, cell infiltration, mainly about the engorged vessels, diapedesis of leucocytes, which can be found free among the tissue deposits of pigment and miliary hemorrhages (Cramer).

*Diagnosis* concerns itself chiefly with the determination of the underlying cause of the delirious condition. Where the case has been watched from the start and a good history can be obtained, this may present little difficulty. The physician, however, is frequently confronted with cases of delirium about whose antecedents he knows nothing, and the problem then is not always easy to solve. The thorough examination of one set of organs after another, which should be the routine in internal medicine, should, however, put us on the right track. Special attention should be paid to the nervous system, the presence or absence of focal symptoms of brain disease being carefully determined, while in obscure cases, lumbar puncture with chemical, microscopical, bacteriological, and serological examinations of the cerebrospinal fluid should be made. A positive Wassermann reaction would suggest syphilis; the characteristic bacteria, respectively, tuberculous, meningococcic, or pneumococcic meningitis; pleocytosis and Nonne-Apelt Phase 1 with positive Wassermann and butyric-acid reaction, general paresis. If there is fever, an infectious disease, especially typhoid fever (confirmed by a bacteriological examination of the blood, or the Widal test) might be suspected; the physical signs in the lungs would indicate pneumonia; a poisoned wound, sepsis; the history of having been bitten by a rabid animal, rabies, etc. The patient's appearance might suggest alcoholism, the black line on the gums lead, etc., while albuminuria with pallor and anasarca and glycosuria would indicate respectively nephritis and diabetes.

Inanition delirium would be suggested by signs of starvation. Evidence of a recent fit—a bitten tongue or blood-stained saliva flowing from the mouth—would speak for epilepsy, while the demonstration of a hemianesthesia or some other stigma of hysteria would clear up the nature of the episode. While it is not as a rule safe to give a positive opinion as to the cause of the delirium, from its character alone, an extremely violent delirium with manic traits and high temperature, an infectious disease being excluded, would speak for acute delirium, while disorientation for place with preservation of sense of personal identity with hallucinations exclusively visual and tremor would suggest delirium tremens.

The *prognosis* of delirium depends upon that of the underlying disease. Delirium acutum is fatal in at least two-thirds of the cases. Delirium tremens has a mortality of from ten to fifteen per cent.

*Treatment* should be addressed to the causative factors. In infectious fevers—especially in typhoid—a rational hydrotherapy will do much to ward off the delirious episode, while in nearly all cases, the warm bath, with cold affusion to the head when indicated, is of great value as a sedative. Where there is great prostration with threatened collapse, stimulation by injections of salt solution into the rectum, or under the skin, brandy, hypodermic injections of camphor in oil, etc., may be called for. In every case it is to be remembered that in active delirium tissue waste is very great and a plentiful supply of easily assimilated food must be given. When the patient refuses nourishment, resort to the feeding tube should not be too long delayed. As a rule the patient will have to be isolated, best in a room with guarded windows, under careful watching. Suitable isolation rooms should be provided in all hospitals and where patients show a tendency to violence or to escape, their removal to such quarters had best not be delayed if a tragedy is to be averted. While in probably the majority of instances, the constant presence and firm control of a robust and experienced nurse will suffice to keep the patient in

bed, if motor unrest is very great mechanical restraint may have to be applied. A stout sheet well tucked in and fastened will suffice in some cases, in others the arms and legs can be secured to the bed by pieces of sheeting, but in the most violent cases a camisole of stout canvas may have to be used. Sedative drugs should be exhibited with caution, especially in the presence of severe constitutional disease, and the milder ones should be preferred. The reduction of temperature in febrile cases may favorably affect the delirium and while for this purpose hydrotherapy is in general to be preferred, in fevers of short duration some one of the antipyretic drugs may be used. A combination of small doses of veronal (gr. iv.–vi) with a little phenacetin (gr. ij–iij) with or without codeine (gr. $\frac{1}{8}$ to gr. $\frac{1}{4}$) has proved of value (v. Noorden). Medinal or trional may also be tried. Alcoholics can take bromides and chloral or paraldehyde with advantage. Hyoscine is a dangerous drug, especially in subjects having any heart weakness, and should be used only in robust cases which cannot be controlled by other measures.

CHARLES LEWIS ALLEN.

**Delusions.**—See *Mental Diseases, General Symptomatology.*

**Dementia Paralytica.**—See *Paralysis, General.*

**Dementia Præcox.**—See *Mental Diseases.*

**Dementia, Senile.**—See *Mental Diseases.*

**Demodex.**—A genus of mites which includes peculiar vermicular forms living in the sebaceous glands and hair-follicles of man and other mammals. These parasites possess a sucking mouth but are usually believed to have no pathogenic importance, though they may help to spread leprosy and other diseases. *D. folliculorum hominis* Simon is cosmopolitan, living in the sebaceous follicles of the face; *D. phylloides* Cook is found in pigs, *D. canis* in dogs, and *D. bovis* Stiles in cattle. See *Arachnida.* A. S. P.

**Demodicidæ.**—A family of atracheate mites, Acarina, containing a single genus *Demodex.* These animals are vermiform, with eight legs, and live in the follicles in the skin of mammals. See *Arachnida.*

A. S. P.

**Demography.**—The term "demography" (Greek: δῆμος, the people, and γράφειν, to write, describe), has not been concisely defined or limited by recognized authorities on a branch of statistical science which within recent years has attained to a position of considerable practical importance. The precedent established many years ago, of combining the terms hygiene and demography, has led to some confusion, but experience has shown the wisdom of this practice, which has the sanction of high authority throughout the world. The first International Congress on Hygiene and Demography was held in Brussels in 1852, and subsequent congresses, including the fifteenth, held in Washington in 1912, have continued the use of the two terms as being more or less inclusive of each other. For the present purpose the term demography has been construed to comprehend the branch of statistical science which especially concerns itself with the movements of population as the result of births, deaths, and migration, and the observed changes resulting therefrom in the composition of the populations as ascertained from time to time by an official census or enumeration of the people, according to age, sex, race, civil condition, etc.

The first user of the term demography, according to an article on the subject in the eleventh edition of the Encyclopædia Britannica, was Achille Guillard, in his Elements de Statistique Humaine ou Demographie Comparée, published in 1855, but the meaning which he attached to it was merely that of a science which treats of the condition, general movement, and progress of populations in civilized countries, little more than what is comprised in ordinary vital statistics gleaned from census and registration reports. The word has come to have a much wider meaning and may now be defined as the branch of statistics which deals with life conditions of people." This conclusion may rightfully be questioned in the light of actual experiences as disclosed by the proceedings of international congresses on hygiene and demography. It is regrettable that these proceedings should frequently have included subjects which apparently are outside of the scope of demography within the definition of the term as adopted for the present purpose, but it does not necessarily follow that, because occasional extraneous subjects were included, this was done on the ground of a broadening conception of demographic science. The first attempt at a scientific definition of the term appears to have been made on the occasion of the International Statistical Congress, held at The Hague in 1869, when Dr. Engel is stated to have made the distinction between statistics as generally understood, and demography in a much more limited sense. With him the word seems to have meant the theoretical portion of the science of social life as derived from statistical observations. This view, in an amplified form, was adopted in the Annals of International Demography, of which the first number was published in March, 1877, and which is practically limited to the facts of population movements, the subjects considered among others being, the method of determining the population of France during the years 1801–1869, the mortality of England during the period 1861–70, migratory movements of the population in Europe and America, sanitary topography, causes of the depopulation of France, etc. Demography is to such a large extent a branch of statistical science that the practice of statistical offices should be more conclusive in attempts to define and limit the term demography than dictionary definitions, often evidently arrived at in disregard of the facts. The word demography is not mentioned in Richardson's Dictionary of 1838; Skeat's Etymological Dictionary of 1882; Latham's Dictionary of 1876; and the edition of Worcester's Dictionary of 1905. The Encyclopædic Dictionary, by Cassell, etc., published in New York in 1882, defines demography as "The science of Races," based on a reference to the subject in Morselli's book on Suicide, first published in 1881. The Standard Dictionary of 1913 defines demography as "The study of vital and social statistics and their application to ethnology and anthropology;" but this definition is quite opposed to the practice of international congresses on demography, and the method of many statistical departments. Equally inaccurate is the definition of demography in the Encyclopædia Americana, according to which "This science deals with the ethnical affinities of nations, and the characteristics, physical and intellectual, that result therefrom." In Webster's Dictionary, edition of 1910, demography is stated to be "The statistical study of populations as to births, marriages, mortality, health, etc., usually restricted to physical conditions or vital statistics, though sometimes applied to studies of moral and intellectual conditions also." The New English Dictionary, Oxford, 1897, defines the term as, "That branch of anthropology which deals with life conditions of communities of peoples, as shown by statistics of births, deaths, diseases." The definition refers to the volume on anthropology in the Library of Useful Knowledge, published in 1880, in which anthropology is divided into two sections, first, anthropology proper, and second, demography,

which treats of statistics of health and diseases. The eleventh edition of the Encyclopædia Britannica, published in 1910, under the term demography, states that it is "The science which deals with statistics of health and diseases, of the physical, intellectual, psychological, and economical aspects of births, marriages and mortality."

None of these definitions is satisfactory and in exact conformity to either the established practice of demographic congresses or the scientific requirements conditioned by the reasonable limitation of the subject-matter considered, and the more or less unconditional exclusion of matters properly within the scope of other and collateral sciences. To define demography as "The science of life conditions of people" would make the term inclusive of practically all that is comprehended under census inquiries, anthropology, geographical pathology, racial psychology, etc., whereas, in the sense of the earlier definitions, and the practice of congresses of demography, the term is intended to be limited primarily to population movements resulting from observed variations in the annual rates of immigration, fecundity, and mortality.

The definitions of demography in medical dictionaries are also quite unsatisfactory and are all more or less indefinite. Dunglison's Medical Dictionary (23rd edition), defines demography as "The study of population in its various aspects." Hoblyn's Dictionary of Medical Terms, 1909, defines the term as "The study of the life conditions of communities from statistical points of view." Durand's Medical Dictionary (4th edition) gives as the definition of demography, "A description of races and peoples and their characteristics." According to Geo. M. Gould, in the 5th edition of his illustrated dictionary, published in 1907, demography is "The science of peoples collectively considered; social science, including that of vital statistics and the consideration of various questions of state medicine." An earlier work, the Encyclopædic Medical Dictionary, by Foster, published in 1890, holds that demography is "The statistical study of human communities, especially in regard to births, marriages, and deaths, and physical, moral, and intellectual development." Dynamic demography is specifically defined as "The study of social movements indicating the rise, progress, and fall of nations," and static demography as "The study of the anatomy of the social groups, as, for instance, of the actual numbers, as well as the properties of inhabitants, their condition as to sex, age, civil state, and profession." This definition would practically make demography the equivalent of a census inquiry and include all vital, social and economic facts having reference to the population considered. Lippincott's New Medical Dictionary, for 1911, gives the curious definition of demography as "Vital statistics as a department of anthropology." Dorland, in his American Illustrated Medical Dictionary, published in 1911, adopted the usual definitions, but adds that static demography is the "collective anatomy of communities and the study of their environment." Finally, according to Stedman's Medical Dictionary (1912), demography is "The science of statistics relating to matters in general—vital statistics, comparative statistics of race, occupation, habitation, etc., in their relation to sickness and health, and to human progress."

Vital statisticians, particularly Westergaard and Newsholme, have not made the term demography the equivalent of what is really a very comprehensive branch of science, and which is inclusive of much which has not necessarily an immediate bearing on the problem of population movement or the causes and conditions responsible for an increase or decrease in the numbers of mankind. The distinction, perhaps, is not of much practical importance, but it would be desirable to have recognized authorities come to an agreement as to the use of terms which are at present more or less ill-defined. In a report published in 1891, on "Denmark, Its Medical Organization, Hygiene and Demography," presented to the seventh International Congress on Hygiene and Demography, held in London in 1891, the section on demography is made to include two divisions, (1) vital statistics, and (2) morbidity and mortality statistics, respectively subdivided as follows: *vital statistics* are made to include population statistics, marriage statistics, condition of workingmen in towns and rural districts, the blind, deaf mutes, the insane, and imbeciles; *morbidity and mortality statistics* are made to include the official collection and publication of medical statistics, the mortality of Denmark during the nineteenth century, the principal causes of deaths in towns, statistics of still-births, infant mortality of the different social classes, trade mortality, mortality of workingmen in towns, mortality of the rural population, and suicides. This arrangement would appear to be entirely too comprehensive to conform to a scientific definition of demography within the generally accepted meaning of the term.

In 1891 the late Joseph de Körösy, for many years the director of the statistical bureau of Budapest, and one of the foremost authorities on statistical science, offered a prize of 1,500 francs, to be awarded to the author of the best essay on the object and progress of demography. The author was required "To particularize the scientific object of demography and criticize the main theories and the most important demographic works of the principal countries of Europe and the United States during the last fifty years." According to a note in the Journal of the Royal Statistical Society for March, 1893, the object of this prize essay was "to bring out chiefly the development of censuses and the progress made in statistics of natality and mortality, and establish where, when and by whom these branches of demographic science had been perfected." The conditions for this prize apparently limited the term demography strictly to the movement of population and the causes and conditions responsible therefor. As far as known the conditions of the request were never complied with and no such essay seems ever to have been published. In 1898, Mr. Edwin Cannan, M. A., contributed an important paper on the demographic statistics of the United Kingdom to the Proceedings of the Royal Statistical Society, divided into three sections: first, movement of the population as dealt with in the Registrar-General's estimate of population; the registration of births and deaths, and the immigration and emigration returns; second, composition of the population by nationality or country of birth, as dealt with in the immigration or emigration returns and the census; and third, internal migration as dealt with in the census returns of birthplaces, by ancient counties and large urban districts, and in the registration of births and deaths by unions. The essay is one of much practical value to students of scientific methods in demography, being a critical consideration of the fundamental facts of population movements and the chances of statistical errors resulting from an indefinite terminology.

An elaborate work on the Hygiene and Demography of the German Empire was published in 1907 as a contribution of the Imperial Health Office and the Imperial Department of Statistics, to the fourteenth International Congress on Hygiene and Demography, held in Berlin in 1907. This work contains no definition of demography, but there is a considerable amount of demographic data in a chapter on Movement of Population, subdivided into five sections as follows: (1) Marriages, births, deaths and migrations; (2) deaths according to age; (3) causes of death; (4) morbidity; (5) the blind and the deaf and dumb. The fifth section has entirely to do with the public health policy of the empire as more or

less conditioned and determined by the foregoing consideration of demographic facts and conclusions.

On the occasion of the International Exposition of Hygiene, held in Dresden in 1911, a special catalogue of statistics was published, which contains a considerable amount of information on the subject of demography, illustrated by numerous charts and diagrams essential for a convenient study of population movements. The section on population statistics includes subdivisions on (1) the progress of population; (2) the age constitution of the population; (3) occupational statistics; (4) the movement of population according to states, cities and special conditions; (5) particular factors conditioning population movement, especially fecundity and mortality; (6) life tables and death rates; (7) mortality during the first year of life; (8) mortality according to civil condition; (9) mortality according to occupation; (10) mortality according to economic well-being, housing, etc.; (11) mortality according to locality; and (12) mortality according to disease.

Among the great statistical offices of the world few are administered with more scientific ability than the Bureau of Municipal Statistics of the City of Buenos Aires, of which Alberto B. Martinez is the director-general. The Bureau publishes annually a yearbook of statistics in the English language, which includes a section on demography. According to the issue for 1910–11, published in 1913, the section on demography is made to include the following principal subdivisions: (1) births; (2) stillbirths; (3) multiple births; (4) increase of births over deaths according to season; (5) marriages; (6) intermarriages; (7) deaths; (8) deaths according to age, sex, cause, etc. The following important demographic elements are not included in the section on demography by the Bureau of Statistics of the City of Buenos Aires, but separately considered in a subdivision on the growth of the population: (1) monthly immigration and emigration; (2) over-sea immigrants; (3) professions of immigrants; (4) sex, civil state and age of immigrants; (5) religions of immigrants; and (6) immigrants classified according to country of emigration. In a separate section on the statistics of trade, the subject of migration in the Republic of Argentina during the last fifty-five years is considered in considerable detail, and also the number of immigrants employed in towns or provinces according to nationality. It is evident that the term demography is used in both a rather restricted sense on account of the exclusion of the elements of immigration, and in a broader sense than the generally accepted one, on account of the inclusion of medical statistics as regards causes of death.

One of the highest authorities on vital statistics, Dr. Jacques Bertillon, for many years the chief of the Bureau of Municipal Statistics of the City of Paris, adopts the following classification of demography in the Annual Statistical Yearbook for 1910, published in 1912: (1) census of the population; (2) mortality; (3) estimate of population since 1680; (4) the principal causes of death; (5) marriages and divorces; (6) births and stillbirths; (7) deaths; (8) contagious diseases; (9) comparative data, statistics for previous years. The subject of migration is not considered.

In 1911 Mr. Thomas A. Welton, a recognized authority on statistics, published an important work on England's recent progress, being an investigation "of the statistics of migrations, mortality, etc., in the twenty years from 1881 to 1901, as indicating tendencies toward the growth or decay of particular communities." This work, while not published under the title of a contribution to demography, is, by its contents, evidently a demographic treatise of the first order of importance. The work is illustrated by a large number of graphics showing precisely the variations in migration and the death rates. The variations are studied in elaborate detail for all the subdivisions of England, with a due regard to the age and sex factors, to emphasize with scientific precision the changes which have taken place in the distribution of the population in small units of territory during the past twenty years. No such elaborate inquiry has been made for the United States, but an excellent illustration of the practical usefulness of this method is William S. Rossiter's essay on the population of Vermont, published in the Quarterly Publications of the American Statistical Association for March, 1911.

One of the most useful contributions to demographic science is the Census of India, which in elaborate detail, exhibits at decennial intervals the changes in the population, with due regard to all the essential factors which, in a study of population movements, require to be taken into account. The Census of Burma, for illustration, for 1911, exhibits in part the distribution of the population, the movement of population, the birthplaces of the people, the religions, the age distribution, the sex, the civil condition, the educational status, the language spoken, the infirmities, the caste, and the occupation. On account of the importance of caste in India the subject was quite carefully reconsidered from modern points of view in a contribution on the subject to the Census of India for 1901, by Nesfield, Ibbeson and Senart. The Census of India is an excellent illustration of modern scientific methods in demography, and from many points of view decidedly in advance of the Census of the United States, particularly with regard to the important element of race. Among the interesting facts revealed by the Census of Burma, for illustration, are the effects of agricultural development on urban population; the evidence of overcrowding in a portion of the city of Rangoon, one section having a density in 1911 of 110,524 persons per square mile; in the decrease in the population of the city of Mandalay, which declined twenty-five per cent. during the intervening decade; the distribution of urban population by religion; the average population to a house; the natural rate of increase of the Buddhist population; the problems of interprovincial migration; the conditions of internal migration; the problem of assisted Indian immigration; the decline in Indian immigration; the abnormal age and sex distribution of Indian immigrants; the immigration of European and allied races, etc.

The subject of migration is of such practical importance in India, including Burma, that special consideration has been given to its various phases, it being properly observed that "Migration is not a phenomenon of uniform type. It varies from the temporary casual visit to a neighboring village, to a permanent removal to a distant country entailing a complete break of association with the country of birth. Though there are an infinite number of gradations between these two extremes, for practical purposes they may be reduced to five, distinguished as follows: (1) Casual, or the minor movements between adjacent villages. (2) Temporary, or due to journeys on business, visits to places of pilgrimage and pagoda festivals, and the temporary demand for labor when new roads and railways are under construction. (3) Periodic, or such as the annual migration which takes place in different tracts at harvest time, and the influx of population into towns having seasonal industries. (4) Semi-permanent, or when the natives of one place reside and earn their living in another, but retain their connection with their own homes, where they leave their families and to which they return in their old age and at more or less regular intervals in the meantime. (5) Permanent, or where overcrowding drives people away, or the superior attractions of some other locality induce people to settle there. It would obviously be of much importance to have this

carefully considered division of types of migration applied to American migratory movements, which were never of such practical importance as they are at the present time.

The essential requirements for the science of demography are, an accurate enumeration of the population at stated intervals of time, and the accurate and complete registration of births and deaths. In addition thereto it is essential to know the facts of immigration and emigration, with a due regard to the place of origin, the race, age, sex, civil condition, and occupation of immigrants and emigrants. Unfortunately the collection of such facts is both costly and technically quite difficult. For the United States at the present time the area of death registration includes only thirty-seven per cent. of the territory, and sixty-three per cent. of the population. The area of birth registration is much less. The statistics of emigration and immigration are practically complete, but it is only of recent years that the information regarding the race of immigrants has been obtained with a reasonable approach to accuracy and scientific principles, best illustrated in the Dictionary of Races, compiled in connection with the work of the United States Immigration Commission. The census of the United States, originally intended only for the enumeration of the inhabitants, has gradually attained to an undertaking of truly colossal proportions. In consequence of the inclusion of new subject-matters of inquiry the tabulation and analysis of the results has been much delayed and the scientific purposes of the work have often been made subordinate to other considerations. As a result, the technical value of the census, with particular reference to demography, is by no means what might reasonably be expected in proportion to the enormous cost of practically all modern census inquiries. At the present time the complete results of the United States Census of 1910 are not available, but a number of preliminary bulletins have been published which disclose important and often far-reaching changes in the composition and distribution of the population. For illustration, out of 2,955 counties which in 1910 constituted the continental United States, 771 decreased in population, and 2,070 exhibited an increase. In 327 of these counties the increase was less than 5 per cent.; in 559 it was from 5 to 15 per cent.; in 369 it was 15 to 25 per cent.; in 366 it was 25 to 50 per cent.; and in 449 counties it was 50 per cent. or more.

The total foreign-born population of the United States in 1910 was 13,515,886. The foreign-born element increased during the intervening period at the rate of 30.7 per cent., but the foreign-born from northwestern Europe actually decreased in numbers, or at the rate of 3.9 per cent. for the intervening period, whereas the foreign-born from southern and eastern Europe increased at the rate of 175.4 per cent. The foreign-born from Asia increased 59.2 per cent., and from North, Central, and South America 13 per cent., and from all other countries, 36 per cent. The distribution of the foreign-born by territorial divisions is of considerable demographic interest, but unfortunately no statistics are available as regards the variations in the birth and death rates, which naturally affect the existing numbers aside from material variations in the number of immigrants annually set forth in much detail in the reports of the Commissioner of Immigration. Of the foreign-born white population in the United States, as enumerated in 1910, 62.2 per cent. had come to the United States in or before the year 1900; 16.7 per cent. had arrived during the period 1901–05, and 21.1 per cent. during the period ending with April 15, 1910.

An important contribution to demography, published in connection with the census of 1910, is the bulletin containing the statistics of population according to the state of birth of the native-born inhabitants. This bulletin exhibits in brief the general extent of the migration of the native population within the United States, the importance of which is shown by the table following:

Population Born in and Living in the United States* and with State of Birth Reported, 1870–1910.

| Census year. | Total. | Born in state of residence. | Born in other states. | |
|---|---|---|---|---|
| | | | Number. | Per cent. |
| 1870 | 32,978,660 | 25,321,340 | 7,657,320 | 23.2 |
| 1880 | 43,475,498 | 33,882,734 | 9,592,764 | 22.1 |
| 1890 | 52,965,719† | 41,871,611 | 11,094,108 | 20.9 |
| 1900 | 65,402,767 | 51,901,722 | 13,501,045 | 20.6 |
| 1910 | 78,095,419 | 61,185,305 | 16,910,114 | 21.7 |

The next table exhibits the facts of interdivisional migration, showing the difference between the total number of native Americans living in each of the nine geographical divisions, and the total number born in each division as returned by the census of 1910:

Population Born in and Living in the United States‡ and with State of Birth Reported, 1910.

| Division. | Born in the specified division. | Living in the specified division. | Gain or loss by interstate migration. |
|---|---|---|---|
| United States: | 78,095,419 | 78,095,419 | ..... |
| New England..... | 4,907,215 | 4,702,088 | − 205,127 |
| Middle Atlantic..... | 15,342,852 | 14,410,385 | − 932,467 |
| East North Central. | 16,479,755 | 15,103,330 | −1,376,425 |
| West North Central. | 9,449,180 | 9,961,467 | + 512,287 |
| South Atlantic. . | 12,770,824 | 11,869,658 | − 901,166 |
| East South Central.. | 9,481,023 | 8,304,102 | −1,176,921 |
| West South Central. | 6,758,408 | 8,392,981 | +1,634,573 |
| Mountain..... . | 1,289,296 | 2,158,616 | + 869,320 |
| Pacific..... | 1,616,866 | 3,192,792 | +1,575,926 |

According to this table there were in 1910, 4,907,215 persons living in the continental United States who were reported as born in New England, while the number of native Americans residing in New England was 4,702,088, or 205,127 less. This difference, according to the census, represents the net loss to New England in the balancing of surviving emigrants; or, as put in another way, "if all persons should return to the division in which they were born, the number of persons coming back to New England would exceed by 205,127 the number of persons leaving New England for other parts of the United States. It is evident that the number of persons reported as born in any division by no means indicates what the native American population of that division would have been had there been no interstate migration on the part of the present generation. If every person now living who was born in New England had remained there, the living children and grandchildren of such persons would have been added to the population of that division; as it is, the children and grandchildren of those who migrated elsewhere appear as natives of other divisions. The converse is true regarding the descendants of persons born in other divisions and now living in New England. Thus while the census makes it possible to measure what may be termed the direct effects of the migration of persons still living, it affords no means of measuring the indirect effects." In continuation of the foregoing, I note the following from the same bulletin with reference to interdivisional migration in other sections of the country: "All divisions east of the Mississippi

* Exclusive of outlying possessions.

† Exclusive of population of Indian Territory and Indian reservations, specially enumerated in 1890, with a native population of 325,451, which, however, was not distributed by state of birth. These areas were not enumerated in 1880 or 1870.

‡ Exclusive of outlying possessions.

have lost more than they have gained as the direct result of the migration of persons still living. The more westerly divisions—the West North Central, West South Central, Mountain, and Pacific—have gained largely by such migration. If all the native Americans in the country should return to the states where they were born, the Pacific division would lose nearly one-half of its native American population."

The complex character of interdivisional migration precludes further consideration, but the subject is one of great practical importance and I cannot omit the inclusion of the following table showing the net gain or loss through interstate migration in the main territorial divisions of the United States for the two census years, 1900 and 1910:

INTERSTATE MIGRATION IN THE UNITED STATES, 1900–1910.

| Division. | Net gain or loss through interstate migration. | | Reduction of loss or increase of gain, 1900–1910 | Increase of loss or reduction of gain, 1900–1910 |
|---|---|---|---|---|
| | 1910. | 1900. | | |
| New England | − 205,127 | − 218,765 | 13,638 | |
| Middle Atlantic | − 932,467 | −1,088,150 | 155,683 | |
| East North Central | −1,376,425 | − 855,449 | | 520,976 |
| West North Central | + 512,287 | +1,328,616 | | 816,329 |
| South Atlantic | − 901,166 | − 950,558 | 49,392 | |
| East South Central | −1,176,921 | − 880,632 | | 296,289 |
| West South Central | +1,634,573 | +1,389,434 | 245,139 | |
| Mountain | + 869,320 | + 525,611 | 343,709 | |
| Pacific | +1,575,926 | + 749,893 | 826,033 | |

I also give a table derived from the census showing the distribution of the population by color or race, nativity, and parentage, for the two census years, 1900 and 1910, and the increase or decrease during the intervening decade, together with the relative percentage distribution of each constituent population element.

The table is of interest as indicating the relative loss in negro population, which declined from 11.6 per cent. in 1900 to 10.7 per cent. in 1910; and the apparent stationary condition of the Indian population, which remains the same for the two census years, but for which there was an actual increase of 12.0 per cent. in numbers during the decade, in contrast to only 11.2 per cent. for the negro, which term is limited to persons of African descent. Of the negro population thus defined, according to the census of 1910, 79.1 per cent. were pure black against 84.8 per cent. in 1890, and 88.8 per cent. in 1850. The actual number of pure blacks in 1910 was 7,777,077, and the number of mulattoes was 2,050,686.

Among the elementary considerations of demographic inquiries are the sex and age constitution of the population. The table below exhibits the results of the census of 1910, showing the actual numbers of the population by divisional periods of life, with distinction of sex, and the percentage distribution of each group.

Material variations occur in the sex and age distribution of the population according to race and nativity, but these cannot be considered here on account of the required brevity.

The marital or civil condition of the United States population is disclosed by the table given below, which also has reference to the year 1910 and which shows

POPULATION OF THE UNITED STATES, BY COLOR OR RACE, NATIVITY, AND PARENTAGE, 1900 AND 1910.

| Class of population. | Number. | | Increase, *1900–1910. | | Per cent. of total population. | |
|---|---|---|---|---|---|---|
| | 1910. | 1900. | Number. | Per cent. | 1910. | 1900. |
| Total population | 91,972,266 | 75,994,575 | 15,977,691 | 21.0 | 100.0 | 100.0 |
| White | 81,731,957 | 66,809,196 | 14,922,761 | 22.3 | 88.9 | 87.9 |
| Negro | 9,827,763 | 8,833,994 | 993,769 | 11.2 | 10.7 | 11.6 |
| Other colored races | 412,546 | 351,385 | 61,161 | 17.4 | 0.4 | 0.5 |
| Indian | 265,683 | 237,196 | 28,487 | 12.0 | 0.3 | 0.3 |
| Chinese | 71,531 | 89,863 | —18,332 | —20.4 | 0.1 | 0.1 |
| Japanese | 72,157 | 24,326 | 47,831 | 196.6 | 0.1 | † |
| All other | 3,175 | | 3,175 | .... | † | .... |
| Total native | 78,456,380 | 65,653,299 | 12,803,081 | 19.5 | 85.3 | 86.4 |
| Total foreign-born | 13,515,886 | 10,341,276 | 3,174,610 | 30.7 | 14.7 | 13.6 |
| Total white | 81,731,957 | 66,809,196 | 14,922,761 | 22.3 | 88.9 | 87.9 |
| Native | 68,386,412 | 56,595,379 | 11,791,033 | 20.8 | 74.4 | 74.5 |
| Native parentage | 49,488,575 | 40,949,362 | 8,539,213 | 20.9 | 53.8 | 53.9 |
| Foreign parentage | 12,916,311 | 10,632,280 | 2,284,031 | 21.5 | 14.0 | 14.0 |
| Mixed parentage | 5,981,526 | 5,013,737 | 967,789 | 19.3 | 6.5 | 6.6 |
| Foreign-born | 13,345,545 | 10,213,817 | 3,131,728 | 30.7 | 14.5 | 13.4 |

* Minus sign denotes decrease.

† Less than one-tenth of one per cent.

DISTRIBUTION OF THE POPULATION OF THE UNITED STATES BY AGE PERIODS, CENSUS OF 1910.

| Class of population and age period. | Population, 1910. | | | Per cent. | | | Males to 100 females. |
|---|---|---|---|---|---|---|---|
| | Total. | Male. | Female. | Total. | Male. | Female. | |
| Under 5 years | 10,631,364 | 5,380,596 | 5,250,768 | 11.6 | 11.4 | 11.8 | 102.5 |
| 5–14 years | 18,867,772 | 9,525,876 | 9,341,896 | 20.5 | 20.1 | 20.9 | 102.0 |
| 15–24 years | 18,120,587 | 9,107,572 | 9,013,015 | 19.7 | 19.2 | 20.2 | 101.0 |
| 25–44 years | 26,809,875 | 14,054,482 | 12,755,393 | 29.1 | 29.7 | 28.6 | 110.2 |
| 45–64 years | 13,424,089 | 7,163,332 | 6,260,757 | 14.6 | 15.1 | 14.0 | 114.4 |
| 65 years and over | 3,949,524 | 1,985,976 | 1,963,548 | 4.3 | 4.2 | 4.4 | 101.1 |
| Total population | 91,972,266 | 47,332,277 | 44,639,989 | 100.0 | 100.0 | 100.0 | 106.0 |

for both sexes the numbers and proportions of the single, the married, the widowed and the divorced, but only for the population of ages fifteen years and over, since the population below age fifteen is practically unaffected by the institution of marriage:

DISTRIBUTION OF THE POPULATION OF THE UNITED STATES BY MARITAL CONDITION, CENSUS OF 1910.

| Marital condition. | Population 15 years of age and over, 1910. | | | |
|---|---|---|---|---|
| | Male. | | Female. | |
| | Number. | Per-cent. of total. | Number. | Per-cent. of total. |
| Single | 12,550,129 | 38.7 | 8,933,170 | 29.7 |
| Married, widowed, or divorced. | 19,720,152 | 60.8 | 21,045,983 | 70.0 |
| Married | 18,092,600 | 55.8 | 17,684,687 | 58.9 |
| Widowed | 1,471,390 | 4.5 | 3,176,228 | 10.6 |
| Divorced | 156,162 | 0.5 | 185,068 | 0.6 |
| Marital condition not reported. | 155,524 | 0.5 | 68,172 | 0.2 |
| Total | 32,425,805 | 100.0 | 30,047,325 | 100.0 |

Of course the distribution of the single and married, widowed and divorced, varies considerably by divisional periods of life, but these variations cannot be discussed here on account of the required brevity; but the facts are briefly set forth in the table below.

DISTRIBUTION OF THE POPULATION OF THE UNITED STATES BY MARITAL CONDITION, CENSUS OF 1910.

| Class of population and age period. | Per cent. of total in specified age group who were | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Single. | | Married, widowed, or divorced. | | Married. | | Widowed or divorced. | |
| | Male. | Female. | Male. | Female. | Male. | Female. | Male. | Female. |
| 15–19 years | 98.3 | 87.9 | 1.2 | 11.6 | 1.1 | 11.3 | * | 0.3 |
| 20–24 years | 74.9 | 48.3 | 24.6 | 51.4 | 24.0 | 49.7 | 0.6 | 1.7 |
| 25–34 years | 35.0 | 20.9 | 64.7 | 79.0 | 62.8 | 75.1 | 1.8 | 3.9 |
| 35–44 years | 16.7 | 11.4 | 83.1 | 88.5 | 79.2 | 80.1 | 3.9 | 8.4 |
| 45–64 years | 10.1 | 8.0 | 89.7 | 91.9 | 80.6 | 70.0 | 9.2 | 21.9 |
| 65 years and over | 6.2 | 6.3 | 93.5 | 93.4 | 65.6 | 35.0 | 27.8 | 58.4 |

*Less than one-tenth of one per cent.

The movement of the population of the United States is at present ascertainable only by means of decennial census enumerations. Statistics of births are available for only a few states and cities, and it is doubtful whether the rates calculated from such a limited area are a trustworthy indication of the fecundity of the nation as a whole. The statistics of deaths, as previously stated, are limited at the present time to sixty-three per cent. of the total population, and thirty-seven per cent. of the land area. Illustrations of population movements as determined by vital statistics must, therefore, be limited to foreign countries, and this is so much more necessary in view of the serious effect of the factor of immigration on the rate of natural increase. The aggregate population of the United States increased during the decade ending with 1910 at the rate of 2.10 per cent. per annum. The comparative percentages for previous decades were, 2.07 for the period 1890–1900, 2.55 for the period 1880–90, and 3.01 for 1870–80. Of course the rate of increase varies considerably for the different geographical sections, but these do not require to be considered on this occasion.

The excess of births over deaths is the most conclusive evidence of normal population growth. The rate of fecundity itself is of great importance, but trustworthy conclusions can only be based on corrected rates calculated on the number of women ages fifteen to forty-four. The excess of births over deaths per 1,000 of population for a few typical countries and for the year 1911 was as follows: Germany, 11.3; Austria, 9.5; Hungary, 9.9; Servia, 14.6; Roumania, 17.3; Bulgaria, 18.8; Italy, 10.1; Spain, 8.1; Switzerland, 8.4; Holland, 13.3; Sweden, 10.0; England and Wales, 9.8; and Scotland, 10.5. On account of the low fecundity of France, where the birth rate is only 18.7 per 1,000, and the death rate 19.6, there was a decrease of 0.9 per 1,000 of population. For certain American States the excess of births over deaths was, for Maine, 5.4 per 1,000; for Vermont, 5.6; for Massachusetts, 9.9; for Rhode Island, 7.5; for Connecticut, 8.8; and for Michigan, 7.6. In Mexico there was a decrease in population on account of an excessive death rate, the birth rate in 1910 having been 29.0, and the death rate 31.1 per 1,000. There was, therefore, a deficiency in births over deaths, equivalent to 2.2 per 1,000.

International vital statistics require to be used with extreme caution for as a rule the crude rates are not corrected for the varying age and sex distribution of the populations. The most useful international data are annually published in the report of the Registrar-General for England and Wales, and by the Bureau of Municipal Statistics of Amsterdam. More elaborate publications are, the international statistics on the movement of the population, published in 1907 by the statistical department of France; the international statistics published in 1908 by Gustav Sundbrarg, Stockholm; and the two volumes of international demographic statistics of the large cities of the world, 1880–1909, published by the Bureau of Municipal Statistics of Amsterdam on the occasion of the thirteenth session of the International Statistical Institute, held at The Hague in 1911. Another important publication on the international statistics of population movements is published annually by the Department of Statistics of Italy, which is illustrated by a number of instructive charts exhibiting variations in death rates and the expectation of life.

An important branch of the department of demographic statistics, in the more comprehensive sense of the term, has to do with physical infirmities, including chiefly statistics of the insane, deaf, dumb, and blind. Several useful reports on these subjects have been published by the U. S. Census Office, but the most valuable data for this country are the decennial census returns of the State of Massachusetts. An instructive report on the statistics of the insane is published annually by the State Hospital Commission of the state of New York. Equally instructive and suggestive are the annual reports of the Commissioners in Lunacy for England and Scotland, which have been issued for more

than half a century, and which contain a vast amount of useful statistical information of a high order of importance in the study of demography. On account of the required brevity this class of demographic facts cannot be discussed in detail, but the following table, showing the rate of insanity per 100,000 of general population, subdivided according to age groups, as published in the report on statistics of the insane of the State of New York for the year 1912, is included as a suggestive illustration of the practical utility of information of this kind:

STATE OF NEW YORK: RATE OF INSANITY PER 100,000 OF GENERAL POPULATION, SUBDIVIDED ACCORDING TO AGE GROUPS.
(Based on First Admissions of 1912 and U. S. Census estimates.)

| Age group. | Number of first admissions, 1912. | Rate per 100,000 of population. |
|---|---|---|
| 10–14 years | 10 | 1.2 |
| 15–19 years | 318 | 35.8 |
| 20–24 years | 621 | 62.8 |
| 25–29 years | 654 | 70.6 |
| 30–34 years | 647 | 80.1 |
| 35–44 years | 1,255 | 90 8 |
| 45–54 years | 894 | 92.1 |
| 55–64 years | 596 | 106.4 |
| 65 years and over | 712 | 161.2 |
| Unascertained | 35 | ..... |

It is also impracticable to discuss at length the statistics of immigration and their usefulness in the study of practical problems of scientific demography. An elaborate report, with numerous statistical tables, is annually published by the U. S. Commissioner-General of Immigration, and corresponding information is published by the statistical offices of practically all the civilized countries of the world. By means of these reports the migratory movements of modern peoples are shown with at least approximate accuracy. During the fiscal year 1912, 838,172 immigrants were admitted into the United States, and in addition thereto, 178,983 non-immigrant aliens. The number of departures during the same year was 333,262 emigrants, and 282,030 non-emigrant aliens. The number debarred for various reasons was 16,057, and the number of emigrants returned after landing, also for a variety of reasons, was 2,456. The foregoing figures have reference only to the migratory movements of the alien population, and the facts stated do not include the passenger movements of American citizens between the United States and foreign countries. The number of such passenger departures in 1912 was 353,890, and the number of arrivals was 280,801. The reports of the Commissioner-General of Immigration contain the required classification of immigrants by occupation, sex, age, literacy, etc., aside from the fundamental distinction of races or nativities, conjugal condition, and in the case of returning immigrants the previous duration of residence in the United States. A vast amount of additional information on the subject of the foreign-born population of the United States is contained in the report of the United States Immigration Commission, published in 1911 in forty-one volumes, including a useful dictionary of races and a statistical review of immigration for the period 1820–1910.

For most of the continental states of Europe accurate information is available regarding the migratory movements of the population, as best illustrated in the methods employed in the construction of the new German life tables, but as concisely set forth in the following statement for the city of Mannheim, for the period 1905–10. The population of the city at the beginning of the period was 163,693, and at the end of the period, 193,902. There was, therefore, an actual increase in population of 30,209, made up, first, by an addition of 4,981 resulting from an increase in territory; second, by an excess of births over deaths of 17,660; and third, by an excess of immigrants over emigrants of 7,568.

What has been said will be sufficient for the present purpose to emphasize the broad scope and practical importance of demography as a branch of statistical science. As an appropriate conclusion attention may be directed to the fact that the fifteenth International Congress on Hygiene and Demography was held in Washington in 1912, and that the subject of demographic science was subdivided as follows:

1. The development of vital statistics in the United States since 1900.
2. The relation of rural and urban populations to public health problems.
3. The classification of causes of death.
4. Diagnoses of the causes of death.
5. The training of demographers.
6. Mechanical methods of tabulating statistics.
7. The present position of municipal vital statistics.
8. Infant mortality in the United States and other countries.
9. Validity of substitutes for the birth rate proposed or used in the United States.
10. American statistics of marriage and divorce.
11. Eugenics and demography.
12. The present condition of criminal statistics in the United States and European countries.
13. Progress toward the construction of life tables for the population of the United States.
14. Statistical basis for a system of pensioning members of the civil service.
15. Statistics of pauperism.
16. Woman in industrial life.
17. The establishment of a series of norms for death rates.
18. The establishment and use of population norms representing constitution according to sex and age, etc.
19. A statistical study of the population of the Riviera.

The enumeration of these nineteen subdivisions conclusively sustains the contention made at the outset that there is urgent need for a concise definition of the term demography and its limitation to practical requirements. Obviously, in the proceedings of the Washington Congress quite a number of subjects were included in the division of demography which properly belong to social and economic science, as not having an immediate bearing on the fundamental problem of demography—that is, the movement of populations and the changes in the constituent elements resulting from such movements, due to variations in the birth and death rates and the migratory movements of persons from one country to another. This, in brief, is the concept of demography, and it is on this account that the development of this science throughout the world has become such an important matter of government concern.

FREDERICK L. HOFFMAN.

**Demours, Pierre.**—Born in Marseilles, France, during the first decade of the eighteenth century. He began his medical studies in Avignon, and continued them in Paris. He received his doctor's cap, however, from the Medical Faculty of the former city, in 1728. Soon afterward he again visited Paris, and was chosen by Duverney, the celebrated anatomist, as his assistant in conducting certain anatomical researches. Upon Duverney's death in 1730, Demours received the appointment of demonstrator and custodian of the cabinet of natural history in the Royal Gardens, but he held this position only up to 1732, when the famous surgeon, J. L. Petit, who was well-acquainted with the qualifications possessed by Dem-

ours, engaged him as an assistant in his anatomical work and also assigned to him the special duty of studying the pathology and treatment of affections of the eye. As a practitioner in diseases of the latter organ Demours soon acquired a well-merited reputation, and his name still appears in the anatomical and ophthalmological manuals in connection with one of the membranes of the eye—Demours's membrane or Descemet's membrane (lamina elastica posterior). He died June 26, 1795.

Of his published writings the following deserve to receive special mention: "Nouvelles réflexions sur la lame cartilagineuse de la cornée, pour servir de réponse à la lettre de M. Descemet," Paris, 1770; "Observations sur la structure cellulaire du corps vitré," Paris, 1741; "Observations sur la cornée," Paris, 1741; "Extrait d'une dissertation sur la mécanique des mouvements de la prunelle, etc.," in *Mémoire des savans étrangers*, Vol. II., p. 586; and a few brief articles on affections of the eye in Vandermonde's *Journal de Médecine*. A. H. B.

**Demulcents** (from Latin *demulcere*—to soothe) are bland substances of a mucilaginous or oleaginous character, which exert a soothing, softening, or protecting influence on the parts to which they are applied. In the past the terms demulcent and emollient have been used somewhat vaguely, and to a large extent interchangeably; but in the present instance demulcent is limited to substances applied internally, to mucous membranes, in opposition to emollients, which are applied to the skin (see article *Emollients*). The chief action of demulcents is mechanical and physical; inflamed surfaces are protected from substances which in passing over them would irritate them; and a protective coating is afforded to any mucous surface which requires lubrication when the natural secretion fails. Thus the respiratory, gastrointestinal, and genitourinary tracts are chiefly amenable to the action of demulcents. The medicinal action, if any, is very slight. The chief demulcent is water; and the various substances which are dissolved in it act mainly as so many means of increasing the adhesiveness of the water. Demulcents allay inflammation, relieve irritation, and quench thirst; and in the genitourinary tract by diluting the urine they diminish its concentration, lessen its acidity, and thus protect the mucous membrane of the bladder and urethra. In the digestive tract, substances like bread and potatoes, if swallowed after the ingestion of pointed articles, afford protection by producing a soft mass in which the foreign substances can become embedded, and in the indigestible residue of which they can travel through the intestines without causing injury, and possibly with little or no inconvenience.

Next to water, the principal demulcents are: Acacia, almond, almond oil, althea, barley, bread, cassia, cetraria, chondrus, elm, flaxseed, figs, licorice, honey, ice, isinglass, lichen, linseed, milk, olive oil, sassafras, syrup, tamarind, tragacanth, wheat, white of egg. R. J. E. Scott.

**Dengue.**—This is an acute infectious disease of tropical and subtropical climates, generally with two febrile paroxysms, intense pain in the joints and muscles, an early erythematous and a late polymorphous eruption, and terminating usually in recovery.

Synonyms.—Dandy fever, break-bone fever, stiff-necked or giraffe fever, scarlatina rheumatica, bouquet fever (sometimes called bucket fever) and *knockel koorts*. The term "break-bone fever" is probably the best descriptive term, as will be attested by those who have suffered from this most painful affection.

History.—It is strange that a disease of such pronounced characteristics and widespread prevalence should not have been reported authoritatively before 1764–68, but such is the case. It was first observed and recorded in Spain during those years, but the first real description of it was furnished by Brylon of Java, in 1779, and this description was greatly amplified by that distinguished American physician, Benjamin Rush, who, under the appellation break-bone fever, gave us a graphic picture of it as it appeared in Philadelphia in 1780.

Many have been its appearances in various portions of the globe. Brylon, who first reported dengue as an epidemic in Batavia in 1779, stated that nearly every one suffered, that the symptoms were much like those ushering in the plague, such as intense headache, terrific pains in the joints and muscles, followed by lassitude. He observed, however, that this epidemic was accompanied by no fatalities, and most of the sufferers recovered from the acute symptoms in about three days under light diet and copious beverages.

After the epidemic in Philadelphia in 1780, we hear no more of it till 1824, when it prevailed in India. Next it appeared during 1827–28 in St. Thomas and Santa Cruz to such an extent that scarcely a single native escaped its doleful touch. In 1828 it appeared in Charleston, S. C., and in 1848–50 another epidemic appeared in the same locality, followed by its rapid spread throughout the Carolinas, Georgia, Alabama, Louisiana and Texas. In this epidemic, Wragg, as quoted by Coleman, affirms that eight-tenths of the inhabitants of Charleston and Augusta were affected.

From 1870 to 1873 it spread over practically the whole of India, and in 1871 it appeared in Arabia, progressing south by lines of travel to Zanzibar and other towns on the East African coast. From there it reached Java and again spread over India. In 1873 it reached the Gulf States of the United States, and the epidemic was quite general, few escaping the infection. In New Orleans it was estimated that over forty thousand suffered during this epidemic. In 1880 an extensive outbreak appeared at Cairo, Egypt, attacking over half of the population, and rapidly spreading through southern Europe. This epidemic soon reached the Gulf States, and some of those interior. In 1885 it appeared in many of the towns in Texas, though but little outside of the State. In 1895 it appeared at Bombay and again widely in Charleston. In 1897 it appeared throughout Georgia, Florida, and Texas, and in this epidemic the writer was enabled at first hand to study many cases. An epidemic of moderate severity prevailed in the Canal Zone during 1904, and since then numerous minor outbreaks have occurred over widely distributed areas. Manson affirms that it reaches pandemic proportions about every twenty years.

Etiology.—It is now rather definitely accepted that dengue is transmitted by the common culicine mosquito of the tropics, *Culex fatigans*, though the proof has not been adduced quite as convincingly as in the case of *Stegomyia calopus* in the transmission of yellow fever. In the nine experiments conducted by Ashburn and Craig, as quoted by Stitt, they threw out five of the cases for such reasons as previous immunity or refusal of the experimental mosquitos to bite. Of the remaining volunteers, only one developed dengue. This man had been on duty at the division hospital, and, so far as could be learned, had not been exposed to the infection. It is also admitted that the mosquitos which bit him had fed on the blood of a dengue patient only two nights previously. If this is to be considered as a valid experiment, we must believe that only a brief sojourn of the virus in the mosquito is requisite, which is at decided variance with eleven days required for the yellow fever virus.

As regards the transmission of this disease by blood filtered through a diatomaceous filter, it should be

remembered that Ashburn and Craig, by demonstrating this fact, placed the dengue virus in the same class with the filterable viruses of yellow fever and pappataci fever. This view as to the latter fever was subsequently strengthened by the report of Doerr.

Graham, of Beirut, as reported in the *Journal of Tropical Medicine*, July, 1903, carried out some experiments, which almost positively demonstrated mosquito transmission. He took mosquitos which had fed on dengue patients to a village in the mountains where no cases of dengue were present. He caused these mosquitos to feed on two natives of the village, and both developed dengue four and five days respectively after being bitten by these mosquitos.

Graham claims further that he noted piroplasma-like organisms in dengue blood, though this claim has not been proved to the satisfaction of other observers.

Another rather convincing chain of circumstances pointing to mosquito transmission is afforded by the fact, as reported by Ross, that dengue was absent in Port Said during the years 1906 and 1907, notwithstanding the prevalence of the disease in adjacent parts of Egypt. This was attributed to the absence of mosquitos, these having been practically destroyed in the fight to make Port Said malaria free.

Dr. Stitt comments on the fact that in the Philippines during 1905 and 1906, when there were no mosquitos about the hospital reservation there were no cross infections among the other and non-immune patients in the same ward. After the onset of the rainy season, however, mosquitos became abundant, in all probability becoming infected, and subsequently transferred the infection.

In view of the above experiments and deductions, we may with a modicum of safety consider dengue as a mosquito-borne disease, with *Culex fatigans* as the carrier.

Pathology.—There seems to have been no distinctive pathological changes noted, though in the epidemic at Galveston in 1885, Paine observed a "localization of inflammation upon the serous membranes," especially in the pleura and peritoneum. Hirsch mentions serous infiltration in the vicinity of joints, and reddening of the crucial ligaments of the knee-joints.

The blood picture has been carefully studied by Stitt, who reports 100 cases in the Johns Hopkins Hospital Bulletin of April, 1913. He claims a characteristic picture may be exhibited even by the second day. In the hundred cases the average leucocyte count was 3,200 per cubic millimeter with a polymorphonuclear percentage of fifty-one. His lowest white count in this series was 1,700, and the lowest polymorphonuclear percentage twenty-nine. These 100 counts were made with a method in which the total count and the differential count were made in the same preparation. A one to twenty dilution of blood was made with a one and a half per cent. of formalin in a half per cent. glycerin in distilled water, to which diluent had been added one drop of Giemsa's stock solution for every cubic centimeter.

It was formerly Dr. Stitt's opinion that the differential count other than that of the polymorphonuclears was of diagnostic value. He is now convinced that the type of leucocyte making up the percentage not taken up by the polymorphonuclears is inconstant, there being at times an increase in lymphocytes, while again the increase may be in the large mononuclears and transitionals. The blood picture is most important as it affords valuable aid in the differentiation from yellow fever.

Symptomatology.—Benjamin Rush, in *Medical Inquiries and Observations*, Philadelphia, 1789, in a chapter describing a bilious remitting fever appearing there, noted that hardly a family escaped, and in many families every member was stricken. The fever came on in various ways—in some a giddiness of the head, sometimes so suddenly appearing that apoplexy was suspected. He was surprised that persons so affected often got well in two or three days. In some cases the onset came with delirium, while the pain was exquisitely severe in the head, back, and limbs. Frequently the pain in the forehead occupied only the eyeballs. In some the muscular and articular pains were so acute that the sufferers could not lie in bed. The disease was thought by many to be a form of rheumatism, but the general name among all classes was *break-bone fever*. Relapses were frequent. In most of the cases a rash appeared on the third or fourth day, which was considered a favorable omen. In some cases the fever was followed by jaundice; in others the exhaustion was greatly prolonged. The epidemic declined in October when the weather became cool.

Coleman describes dengue as a disease of three stages, viz., (1) invasion, lasting from two to five days; (2) remission, lasting from twelve hours to three days; and (3) a return of the symptoms of invasion, lasting from twenty-four to thirty-six hours, in which none of the symptoms are as severe as during the first paroxysm.

There is no definite prodromal period, the dengue generally coming on suddenly with rapidly rising temperature and speedy assembling of all the acute symptoms.

In few diseases is the patient more woe-begone and melancholy. He complains of marked soreness in the eyeballs, so that every movement of the eyes provokes intense pain. He complains bitterly of insufferable pains all over the body, especially of the back and the tendinous insertions of the muscles, which cause the pains to be referred to the joints—hence the name break-bone fever. The pain in the back may be as great as in yellow fever, while a stiffness about the back and neck produces that peculiar posture which originated the designation dandy fever. Prostration is intense and is a prominent symptom. In children it may be ushered by a convulsion, while delirium is rather common in both children and adults. Passive motions of the limbs and joints are not attended with great pain, but any effort on the part of the patient to move is provocative of agony. A peculiar feature of the joint manifestations lies in the fact that while the pain may be almost intolerable, there is no swelling and but little sensitiveness to pressure.

There is a rise of temperature, which is rather continuous until the end of the second to the fifth day, when it reaches its maximum. This temperature, which varies from 100° to 103° in ordinary cases, and sometimes reaches 107° or more in severe ones, is accompanied by a pulse at first full, bounding, and rapid, but after a few days becomes noticeably slow. This slow pulse, which was noted also by Rush, does not generally become accelerated in proportion to the fever, and even in the second accession of pyrexia may be as low as forty-five beats per minute.

Anorexia is always present, and in some cases marked nausea and vomiting. The vomiting with concomitant jaundice which has appeared in some epidemics has led to difficulties in diagnosis, especially when yellow fever was prevalent in other sections of the country. This anorexia extends well into convalescence, often in connection with malaise, lack of interest in surrounding objects and events, and a sense of pessimism and discouragement which clouds the mental horizon and clothes each waking thought with a mantle of gloom.

The bowels are frequently constipated at first, but diarrhea often supervenes toward the later stages. The urine is usually high colored, but is never suppressed, and rarely albuminous. There are no changes in the urine characteristic of dengue.

Hemorrhages from the mucous surfaces occasion-

ally occur, and one observer (Foster) states that "there is always a tendency to hemorrhages from these surfaces, and, in females, especially from the womb." He also saw some cases of black vomit, and the suspicion is aroused that possibly yellow fever was mistaken in some instances for dengue.

The eruptions are two-fold, the first being a vasomotor erythema coming on with the first accession of the fever, and the second, the true eruption, which occurs at the second accession of fever, whether this follows the remission or intermission. The initial eruption varies from a simple redness to a distinct erythema, depending somewhat on the character of the patient's skin, whether dark or fair. It shows first on the face, causing it to swell, while there is tumefaction of the eyelids and suffusion of the conjunctivæ. This may extend to the nasal and pharyngeal mucous membranes, and occasionally over the whole body, but its duration is short. The secondary rash, occurring usually on the fourth to sixth day, is more characteristic, and is considered by some as pathognomonic. This, however, is incorrect, as in some epidemics not over forty per cent. of those affected showed this rash. It appears first on the palms and backs of the hands, extends up the arms, and is also found on the trunk, thighs, and legs. Generally it first shows as small elevated circular spots, dusky red in color, disappearing on pressure, and tending to coalesce with contiguous spots, making irregular patches two or three inches in diameter. While there are often normal areas on the skin between these patches, in some instances the whole integument may be covered, lending a scarlatiniform appearance. It begins to disappear after about twenty-four hours, followed by some desquamation, bran-like, and never in large flakes. Sometimes, when fully developed, this eruption is accompanied by intense itching and burning. Some enlargement of the lymphatic glands of the neck, axillæ, and groins is occasionally in evidence when the fever begins to remit.

Differential Diagnosis.—The suddenness of the onset of dengue, as well as its terrific pains, especially coupled with its epidemic tendency, generally stamps the diagnosis with ease. The most important consideration in connection with this disease is its differentiation from yellow fever. This differentiation, according to Stitt rests best in:

(1) The normal urine of dengue and the albuminuria of yellow fever.

(2) The striking blood picture of leucopenia and marked diminution in polymorphonuclear percentage of dengue with normal findings in yellow fever.

(3) The jaundice appearing about the third day in yellow fever and the characteristic eruption in dengue showing itself from the third to the fifth day.

Where epidemics of dengue and influenza are concurrent there is need of differentiation, for some severe attacks of the latter closely simulate dengue.

Influenza is not confined to mosquito zones, while dengue is. Influenza spreads over whole countries rapidly, while dengue is mainly noted on sea coasts, valleys of large rivers, and busy lines of travel. Fever is not always present in influenza, or, if present not very high, while dengue presents a high temperature. Pain in influenza is an incident, but in dengue it is the most prominent symptom. Probably the most enlightening symptom is the pulse, which varies with the temperature in influenza, while in dengue it remains markedly slow after the first remission. It might be mentioned also that convalescence is generally rapid after an uncomplicated attack of influenza, while it is tardy in dengue, leaving the patient prostrated, anemic, and thin, and liable to exacerbations of pain for several weeks. Influenza, too, is accompanied by acute catarrhal symptoms absent in dengue; and finally the presence or absence of the influenza bacillus should "clinch" the diagnosis.

Malaria, while occurring frequently in the same sections, and at the same seasons of the year, does not occur in such epidemic form. The febrile disturbance differs from dengue, and is relieved by quinine, whereas this drug has no effect on dengue. The presence of the plasmodium malariæ, if shown, would render the diagnosis clear.

Differentiation from rheumatism should not be difficult, if the various symptoms are thoughtfully analyzed.

Occasionally dengue would seem to resemble scarlatina in the rash and high fever; but scarlatina is mainly a disease of childhood, while dengue attacks all ages. Scarlatina, also, occurs in all seasons, has the characteristic "strawberry tongue," and ulcerated fauces, is a disease of one paroxysm, is not attended by terrific muscular and joint pains, and is followed by such extensive desquamation, that the diagnosis should at no time be in doubt.

Prognosis.—Except those affected with some other serious disorder, the prognosis is favorable. It is a remarkable fact that this disease, one of the most acute in the whole category of human ailments, possesses a mortality absolutely negligible; and it is doubtful if there is a single case on record where an uncomplicated attack of dengue proved fatal.

Prophylaxis.—Arguing that dengue is transmitted by the mosquito *Culex fatigans*, and only by that means, the indications for prophylaxis are evident. In the absence of this pest, dengue cannot spread, and to eliminate it from a community, swamp lands must be drained or thoroughly oiled; cisterns and cesspools, dwellings, places of business and offices should be screened, and every effort directed toward the extermination of this mosquito. The efficiency of such methods was well demonstrated at Port Said, as previously mentioned. Infants, invalids, and old persons should be specially protected in times of epidemics.

Treatment.—No specific therapy for dengue has been discovered, nor any means by which immunity may be conferred. The treatment is entirely symptomatic, and must of necessity be energetic. The sufferers from this distressing malady are so acutely ill, and the pains so multitudinous and excruciating, that any hesitation or dalliance on the part of the physician will be hailed with bitter complaint and frenzied appeals for speedy action.

It was noted by Dr. Rush that those who gave up to the illness, making no effort to fight it off, enjoyed a much more rapid convalescence. This is corroborated by the experience of those on board the French ship *Cher*, which was wrecked off the coast of New Caledonia in 1884. There was at that time an epidemic of dengue prevailing, and we are informed that at the time of the wreck those who were in the first days of the disease preferred to risk the chances of death rather than be disturbed. Those who were recovering, however, lent valuable assistance in the rescue work, and practically every one of these underwent a tedious convalescence, while those who put forth no efforts were soon well.

Every sufferer from dengue, no matter how seemingly mild, should be put to bed, and kept there until all the acute symptoms have subsided. There should be no compromise regarding this.

The diet should be liquid during the first stage—in fact the anorexia and nausea are so pronounced that but little can be either ingested or retained. Slightly acidulated albumins are often relished, and buttermilk is frequently kept and assimilated when sweet milk is rejected. Any nourishing form of liquid food may be given during this stage, judgment being of course exercised by the medical attendant. After convalescence begins the nourishment should be nutritious with as large protein con-

tent as the patient can assimilate. Ingenuity should be employed to tempt and please finical and jaded palates, otherwise but little will be eaten, and the gain in strength will be distressingly slow.

Copious use of cooling drinks is both beneficial and grateful, and is generally demanded by the patients. The gently acidulated and carbonated beverages are often craved, and may be given *ad libitum* without detriment.

At the onset of the disease a gentle laxative may be exhibited in order that the alimentary tract may be cleared and the excretory pathway opened. The pains in the joints and muscles will demand the most care, and are generally relieved by the coal-tar preparations, as antipyrin, acetphenetidin, acetanilid and acetylsalicylic acid in doses repeated as often as may be permitted with safety. These failing, some form of opium may be necessary, the hypodermatic use of morphine or codeine being preferable. Salicylic acid and the salicylates are without value, and quinine exerts no beneficial effects whatever. Strychnine or ammonia may be indicated for the slow and "sulky" pulse. Seldom are any forms of alcohol of real benefit. For the sleeplessness, which is often annoying even after the pains are controlled, trional and veronal are useful, and are less liable to upset the stomach than either bromide or chloral.

Hydrotherapy finds a serviceable field in the management of dengue, and by the employment of hot baths, the temperature may be reduced and the nervous symptoms abated. Occasionally cold applications are more soothing, especially in the presence of abnormally high temperature. Hot packs have given great relief in some instances; likewise hot fomentations, either moist or electric light. Hot or cold sponge baths, as preferred by the patient, are also frequently of decided benefit.

External applications, though of doubtful value, have their place for a twofold reason—they exert a certain amount of counterirritant effect, and they convince the patient that something is being constantly done for the relief of pain. The combinations of turpentine with spirit of camphor, chloroform, capsicum, oil of wintergreen, or other eligible preparations are of use. Also there are now obtainable counterirritant ointments in which are capsicum, mustard, or menthol, with a vaseline base, and which are both convenient and efficacious in the relief of the pains. These may be rubbed on as often as desired.

During the convalescence the various tonics are appropriate, and in this stage iron, arsenic, nux vomica, and others of this class have their useful place. For the nervous depression and pessimism the compound glycerophosphates, either by mouth or hypodermatically seem to brace and cheer the drooping spirits.

If practicable, the invalid should be sent to a cooler climate, and if baths, massage, electricity, and outdoor recreations are available, the convalescence will be correspondingly hastened.

It is highly beneficial that the general environment should be cheerful and agreeable, so that the tendency to discouragement and pessimism may be overcome, and the gloomy spirits be uplifted. In no disease are tact, patience, and cheery optimism more demanded on the part of the medical attendant than in the treatment of this most distressing malady, but fortunately he may expect positive and gratifying results from well-directed efforts.

GEORGE M. NILES.

**Denison, Charles.**—Born November, 1, 1845, in Royalton, Vermont. He received the degree of Doctor of Medicine, in 1869, from the University of Vermont. He began the practice of his profession in Hartford, Conn., but his health becoming impaired he took up his residence in Denver in 1873, and devoted himself for a long time to the study of climate in relation to the cure of pulmonary diseases. As Professor of Diseases of the Chest and Climatology in the Medical Department of the University of Denver, and as President of the American Climatological Association, he became widely and favorably known to the Profession throughout the United States. His death occurred on January 10, 1909. He contributed to medical literature a large number of articles on topics relating to his special branch of knowledge. A. H. B.

**Denman, Thomas.**—Born at Bakewell, Derbyshire, England, June 27, 1733. At the age of nineteen or twenty he began the study of medicine in St. George's Hospital, London; but, at the end of a few months, he was compelled, through lack of funds, to accept a position as surgeon in the marine service. In 1763 he resigned his office and returned to London, where he devoted himself particularly to the study of obstetrics, under the guidance of Smellie, the great authority of that day in this branch of medical knowledge. Later, he became associated with Dr. William Osborn in the work of teaching midwifery, and his efforts were awarded with marked success.

He was next appointed Attending Physician and Obstetrician to the Middlesex Hospital, and eventually he rose to be the leading authority, at that period in England, in his specialty. He died in 1815 at the age of eighty-two.

Of his published writings the following deserve to receive special mention: "Essays on the Puerperal Fever, and on Puerperal Convulsions," London, 1768; "Aphorisms on the Application and Use of the Forceps in Preternatural Labors, and in Labors attended with Hemorrhage," London, 1786 (several later editions were published); an "Essay on Natural Labors" and another on "Preternatural Labors" were published in London in the same year; "Introduction to the Practice of Midwifery," two volumes, London, 1787 (later editions in 1789, 1795, and 1805); "Observations on the Rupture of the Uterus, on the Snuffles in Infants, and on Mania Lactea," London, 1809; and "Case of Successful Extirpation of a Polypus Uteri; also a Case of Premature Delivery," in Med. and Phys. Journal, 1800. A. H. B.

**Dentifrices.**—The word dentifrice is older in literature than might be thought for it occurs in Blount's Glossary, Edition 1674; in Ben Jonson, Catiline, act ii.; also in Holland's Pliny. The derivation is definitely significant of its meaning, Latin, *dens*, a tooth, and *fricare*, to rub. The Latin dentifricium means tooth-powder. Our modern term dentifrice includes not only tooth-powders, but other preparations as well—pastes, soaps, and lotions used for cleansing the teeth.

The care of the buccal cavity and teeth is a matter of extreme importance and the preparations used for the purpose of keeping the mouth and teeth clean should be both effective and harmless. On account of the many bacteria present and the rapid decomposition of residual organic matter almost constantly present in the mouth and about the teeth the use of antiseptic preparations is a matter of necessity.

Before referring to some of the many dentifrices that are offered for use it may be worth while to consider the effect of various medicinal substances on the teeth. Koller gives the following results of Maurel's investigations: "Copper sulphate turns the sound enamel of the teeth a muddy yellow color; it seems to attack the cement, and stains both this and the dentine a permanent green, which shows through the enamel. Potassium chlorate has no action on the teeth. (This statement is contradicted.) Silver nitrate does not corrode the teeth, but imparts a black metallic sheen thereto. Alum is very destruc-

tive to the enamel. Its action on the dentine and cement varies, and is but weak; the cement is less affected than the dentine. Alcohol has no action on dental enamel. Benzoin tincture does not affect the structure, but when constantly used, colors the dentine and cement brown. Peppermint tincture does not affect the hard tissue, but stains the roots of the teeth brown. Eau de Cologne has no action. Tobacco juice does not act on the structure of the teeth, but stains them more or less brown. The enamel is only slightly affected."

Medalia declares that dentifrices containing a high percentage of potassium chlorate are injurious. Such preparations may cause very marked recession of the gums and grooving of the enamel. This deleterious action is probably due to the free chlorine that is liberated from the potassium chlorate.

In regard to the various forms of dentifrices, the choice of tooth-powders especially demands the nicest discrimination, since certain attritive substances injurious to the enamel form so common an ingredient. Although under ordinary circumstances, the hard vitreous-like enamel offers excellent protection to the mass of porous bone that it encloses, it is nevertheless very susceptible to sudden temperature changes by which it is easily cracked. The way is then open for destruction of the tooth. Pumice stone in tooth-powder serves to scour the surface of the tooth, but at the same time, unless extremely fine, it really files away the enamel. Charcoal, too, in spite of its marked disinfectant action, has practically the same effect due to the silica that it always contains. Silica will scratch even glass.

A recent summing up of the essentials of a good dentifrice has been given by Prinz: "It must be absolutely indifferent in regard to the mucous membrane of the mouth—*i.e.* it must be non-caustic; as regards the teeth, it must be non-decalcifying; as regards the organism as a whole, it must be non-poisonous. It must have sufficient antiseptic action. It must have a pleasant taste and odor."

The basis of a good tooth-powder may be precipitated chalk, magnesia, or orris-root powder; other ingredients commonly used are myrrh, soap, pumice stone, and cuttlefish bone. In order to improve the taste, saccharin or licorice may be added. Sugar, as will be explained later, is apt to prove injurious to the teeth. The most popular flavors are oils of peppermint and wintergreen.

The ingredients of tooth-powders should be triturated and sifted to very fine powder, and finally should be intimately mixed.

As to the coloring agents—extremely valuable and interesting experimental work has been done recently by McGehee in relation to the tooth-staining properties of various-colored dentifices. It is well known that dental structure may be discolored by such agents as the essential oils, silver nitrate, iodine and potassium permanganate.

Comparatively few investigations, however, had been made before McGehee's work with regard to the effects of the coloring agents of dentifrices. From this view point dentifrices may be classified as colorless or practically so, and colored. The greater number of the latter class contain some definite dye or coloring agent, while others have the color resulting from the mixture of their ingredients. In general the artificial coloring agents have no special medicinal value but are used for the purpose of appearance.

Between 400 and 500 formulæ, American, English, German, and French, have been examined to determine the names and percentage of employment of the various coloring agents used in dentifrices. The colors imparted to these preparations are chiefly red, cherry red, reddish-brown, violet red, pink, purple, violet, brownish-red, golden yellow, brown, green, blue, and brownish-yellow.

These coloring agents are cochineal, cudbear, alkanet, hematoxylon, red saunders (red sandalwood), saffron, caramel, chlorophyl, aniline red, aniline blue, methyl violet, erythrosin, Congo red, Prussian blue, catechu, indigo, vermilion, Brazil wood, azo orange R., and in addition various authorities mention alizarin madder, Venetian red, Florentine lake, smalt, red coral, tincture of hempseed, and amber. As a result of his extensive investigations, McGehee concludes that: Colored dentifrices constantly used in the mouth will produce staining of tooth structure, and for that reason should be abandoned in favor of colorless preparations.

Two German investigators, Kuester and Weisbach, after making most painstaking and extensive investigations into the cleansing and bactericidal effects of numerous dentifrices, including mouth-washes, in common use both in the United States and abroad, have concluded that disinfection of the oral cavity by rinsing with the preparations ordinarily used seems impossible of accomplishment.

The oral flora, they declare, are never reduced more than fifty per cent. by cleansing with tooth-brushes and the many dentifrices that are not injurious to the organism. An equal reduction in the oral flora can be obtained by the combined use of ordinary white clay and physiological salt solution. This normal salt solution is isotonic, and is absolutely non-irritating; and white clay is a fine mechanical cleanser. Should the taste be objected to, Goldhammer proposes argilla as a substitute for the white clay. The former combined with catechu, an astringent, offers an excellent, cheap, and aromatic tooth-powder which was recommended by the International Commission for Public Oral Hygiene in 1912.

In a recent article on Mouth Hygiene and Oral Prophylaxis, Sarrazin emphasizes the importance of cleansing the teeth with flat dental floss charged with polishing powder rich in germicidal properties. This powder should vary according to individual conditions.

A word of caution about the brush must be added. The bristles should be of medium stiffness neither too harsh nor too soft.

Powders.—Plain levigated chalk perfumed with a few drops of oil of peppermint is highly praised as a tooth-powder. The chalk is cleansing and the peppermint oil is refreshing and stimulating.

Hufeland's tooth-powder is made after this formula:

| | | |
|---|---|---|
| ℞. | Cort. chin. fusc. | 10.0 |
| | Lign. santal. rub | 45.0 |
| | Alum. crud. | 5.0 |
| | Ol. caryophyll. | |
| | Ol. bergam. | āā gtt. viii. |

M.; ft. pulv. subtilissim.

Other formulas are the following:

Salicylated Tooth-powder.

| | | |
|---|---|---|
| Sodium salicylate | | gr. 120 |
| Sodium bicarbonate | av. oz. | 4 |
| Precipitated chalk | av. oz. | 16 |
| Myrrh | av. oz. | ¾ |
| White castile soap | av. oz. | 1½ |
| Orris root | av. oz. | 3 |
| Licorice | av. oz. | 2 |
| Oil of wintergreen | drops | 3 |
| Oil of rose geranium | drops | 30 |

A very popular preparation is saponaceous tooth-powder:

| | |
|---|---|
| Powdered white castile soap | av. oz. 8 |
| Precipitated chalk | av. oz. 4 |
| Magnesium carbonate | av. oz. 2 |
| Powdered sugar | av. oz. 2 |
| Oil of wintergreen sufficient to flavor. | |

Another article high in popular favor is camphorated tooth-powder:

| | |
|---|---|
| Prepared chalk | av. oz. 8 |
| Orris root | av. oz. 4 |
| Camphor | av. oz. 2 |
| Cinnamon | av. oz 1 |

A rose tooth-powder is of simple composition:

| | |
|---|---|
| Prepared chalk | av. oz. 22½ |
| Sugar of milk | av. oz. 8 |
| Powdered orris root | av. oz. 1½ |
| Carmine | gr. 16 |
| Oil of rose | drops 16 |

An astringent tooth-powder has these ingredients:

| | |
|---|---|
| Myrrh | 1 |
| Sodium chlorate | 1 |
| Soap | 0.50 |
| Precipitate calcium carbonate | 50.0 |
| Rose oil | q.s. |

Oxygen Tooth-powder.

| | |
|---|---|
| Precipitated chalk | ʒ 6 |
| Sodium perborate | ʒ 1 |
| Powdered soap | gr. 20 |
| Oil of wintergreen | ♏ 15 |

A Tooth-powder with Cuttlefish Base.

| | |
|---|---|
| Cuttlefish | 8 ounces. |
| Cream of tartar | 4 ounces. |
| Orris root | 2 ounces. |

A formula often prescribed is:

| | | |
|---|---|---|
| ℞. Magnes. carb. | 20.0 | ʒ v. |
| Calc. carb. præc. | 80.0 | ʒ xx. |
| Sap. med. pulv. | 15 0 | ʒ iv. |
| Ol. menth. pip. | 2.0 | ʒss. |

A simple but good tooth-powder is made of:

| | |
|---|---|
| Precipitated chalk | av. oz. 16 |
| Powdered castile soap | av. oz. 1 |
| Powdered licorice root | av. oz. 1 |
| Magnesium carbonate | av. oz. 2 |

The powder may be tinted with carmine and flavored according to individual taste.

Thymol tooth-powder is compounded according to the following formula:

| | |
|---|---|
| Precipitated chalk | av. oz. 15 |
| Powdered white castile soap | av. oz. 1 |
| Saccharin | gr. 10 |
| Thymol | gr. 15 |
| Camphor | gr. 30 |
| Vanillin | gr. 5 |
| Oil of rose | drops 6 |

A tooth-powder containing quinine is sometimes desired:

| | |
|---|---|
| Prepared chalk | 15 ounces. |
| Cuttlefish | 1 ounce. |
| Orris root | 1 ounce. |
| Myrrh | ½ ounce. |
| Sulphate of quinine | 10 grains. |

Camphorated Chalk.

| | |
|---|---|
| Camphor | 1 ounce. |
| Precipitated chalk | 15 ounces. |

Salol Tooth-powder.

| | |
|---|---|
| Salol | 4 grams. |
| Calcium phosphate | 20 grams. |
| Calcium carbonate | 20 grams. |
| Magnesium carbonate | 20 grams. |
| Sodium bicarbonate | 15 grams. |

Peppermint oil, sufficient to flavor.

Sometimes borax is used:

| | |
|---|---|
| Borax | 50 ounces. |
| Chalk | 100 ounces. |
| Myrrh | 25 ounces. |
| Orris root | 22 ounces. |
| Cinnamon | 25 ounces. |

An antiseptic strontium tooth-powder consists of:

| | |
|---|---|
| Strontium carbonate | 150 grains. |
| Prepared chalk | 375 grains. |
| Calcined magnesia | 375 grains. |
| Salol | 90 grains. |
| Thymol | 15 grains. |

Sufficient carmine solution to tint and oil of peppermint to flavor.

A large proportion of cream of tartar is sometimes prescribed:

| | |
|---|---|
| ℞. Rad. irid. flor. | 11.5 |
| Cream. tartar. | 15.0 |
| Cort. chin. fusc. | |
| Cort. cinnam. | āā 2.0 |
| Ol. amygdal. amar. | gtt. ii. |
| Ol. rosar. | gtt. i. |

M., ft. pulv. subtilissim.

A camphor tooth-powder is compounded of:

| | |
|---|---|
| Camphor | 0.500 |
| Soap | 1.000 |
| Saccharine | 0.025 |
| Thymol | 0.050 |
| Calcium carbonate, precipitated | 50.000 |
| Oil of sassafras | 1 to 2 drops. |

Arnica Dentifrice.

| | |
|---|---|
| Powdered quillaja | 4 ounces. |
| Powdered orris root | 3 ounces. |
| Precipitated chalk | 3 ounces. |
| Tincture of myrrh | 1 dram. |
| F. E. arnica | 2 drams. |
| Oil of rose geranium | 30 drops. |
| Oil of sandalwood | 5 drops. |

Sarrazin advocates the use of dry powder on a dry brush twice a day—after breakfast and at bedtime. The powder should vary according to the conditions present.

One of these preparations contains: Zinc perborate, strontium peroxide, boric acid, tannin, zinc sulphate, menthol, thymol, sodium bicarbonate, benzoic acid, ossis sepiæ, precipitated chalk, orris root and vegetable flavoring.

A powder useful in Riggs' disease consists of: Sodium chloride, benzoic acid, sodium bicarbonate, boric acid, zinc sulphate, menthol, thymol, eucalyptol, phenic acid, ossis sepiæ, and vegetable flavoring. Once a day this powder is to be made into a thick paste with water. After flat floss is entered between two teeth, the paste is packed there with a manicure stick, and is then rubbed vigorously against each tooth in turn, all the teeth in both upper and lower jaws being carefully polished in this way.

The first powder is less active in grit than the second, although both are passed through a sieve with 120 meshes to the linear inch. The former has the stimulant, astringent, and germicidal properties appropriate to the usual mouth conditions, and is without irritating effects.

In order to correct tannin stains a polishing powder similar to the one last mentioned is used. This powder in addition to the ingredients already given contains a little pumice. Although pumice, be it never so fine, will show angularity under the microscope, nevertheless, after having been brought to number 120 fine, its use may be continued for months without any harm.

Creams and Pastes.—In addition to powders for the teeth which are legion, there are probably as many creams and pastes. Pastes are considerably stiffer in consistence than the creams.

Creams as a rule are packed in collapsible tubes; while pastes are usually sold in jars. Creams almost invariably contain powdered soap.

A cream or paste may be made from tooth-powder by incorporating glycerin, honey, or simple syrup.

Hard tooth-pastes are called tooth-soaps. These preparations generally contain twenty per cent. of soap. Otherwise the ingredients are practically the same as those of pastes. Spirit of wine is sometimes used to form the cake.

Similar coloring agents and perfumes are employed in all of these preparations. Creams and pastes, like the powders, not infrequently contain substances injurious to the teeth. Others are excellent for their purpose.

MYRRH TOOTH PASTE.

| | |
|---|---|
| Precipitated chalk | 8 ounces. |
| Orris root | 8 ounces. |
| White Castile soap | 2 ounces. |
| Borax | 2 ounces. |
| Myrrh | 1 ounce. |
| Glycerin, sufficient to make a paste. Color and perfume to taste. | |

A eucalyptus tooth paste is made up of 160 grams of precipitated chalk—levigated chalk—forty-five grams of soap powder, forty-five grams of wheat starch, one gram of carmine, thirty drops of peppermint oil, thirty drops of geraniun oil, sixty drops of eucalyptus oil, twelve drops of clove oil, and twelve drops of aniseed oil. These ingredients are mixed together and made into a paste with a mixture of glycerin and alcohol, equal quantities.

SALICYLATED TOOTH PASTE.

| | | |
|---|---|---|
| Precipitated chalk | av. oz. | 16 |
| Powdered white Castile soap | av. oz. | 4 |
| Powdered sugar | av. oz. | 4 |
| Powdered orris root | av. oz. | 4 |
| Powdered pumice | av. oz. | 1½ |
| Sodium salicylate | gr. | 80 |
| Glycerin | fl. oz. | 2 |

MENTHOLATED TOOTH CREAM.

| | | |
|---|---|---|
| Precipitated chalk | av. oz. | 8 |
| Powdered white Castile soap | av. oz. | 4 |
| Magnesium carbonate | av. oz. | 2 |
| Menthol (dissolved in alcohol), | | |
| Carmine solution, | | |
| Glycerin āā | q.s. | |

The first three ingredients are rubbed to a paste with glycerin, and are then flavored and colored to taste with the solutions of menthol and carmine.

Another tooth cream is composed of:

| | | |
|---|---|---|
| Precipitated chalk | av. oz. | 8 |
| Powdered white Castile soap | av. oz. | 4 |
| Powdered orris | av. oz. | 4 |
| Oil of sassafras | drops | 40 |
| Oil of bay | drops | 8 |
| Honey | av. oz. | 13 |

Frohmann, a Berlin dentist, advocates the use of the following tooth soap: Thymol, 0.25, ratanhia extract, 1.0 in 6.0 of hot glycerin, calcined magnesia, 0.5, sodium biborate, 4.0, medicinal soap sufficient to make the preparation up to 30.0, peppermint oil, 1.0.

This soap is to be used after dinner and before retiring.

Another formula used is:

| | | |
|---|---|---|
| ℞. Rad. irid. pulv | | 7.5 |
| Sap. hispanic | | 12.5 |
| Adde successive: | | |
| Ol. caryophyll | gtt. | viii. |
| Aq. dest., | | |
| Spt. vini rect āā | | 5.0 |

Still another preparation contains rhatany:

| | | |
|---|---|---|
| Powdered white Castile soap | av. oz. | 10 |
| Tincture of rhatany | fl. oz. | 3½ |
| Precipitated chalk | av. oz. | 3½ |
| Benzoic acid | av. oz. | ½ |
| Powdered potassium chlorate | av. oz. | ½ |
| Powdered borax | av. oz. | ½ |
| Saccharin | gr. | 10. |
| Oil of cinnamon sufficient to flavor. | | |

These ingredients are mixed with glycerin and water, pressed into tin boxes and dried.

To give more of these formulas would be practically a repetition. And notwithstanding the variety of dentifrices offered for use, many of complicated make-up, the fact remains—the simpler the dentifrice, the better. Any preparation that can saponify the particles of food lodged in the buccal cavity will do good service. Simple castile soap and warm water applied with a clean brush equal the best of prepared tooth-pastes, and this simple treatment can never do any harm.

LIQUID DENTIFRICES or tooth washes are made from quillaja or soap. These preparations are sometimes substituted for powders, creams, pastes, and soaps. They are colored and flavored according to taste.

TOOTH WASH.

| | | |
|---|---|---|
| Quillaja, coarse powder | av. oz. | 1½ |
| Powdered cochineal | gr. | 15 |
| Glycerin | fl. oz. | 3 |
| Oil of wintergreen | drops | 25 |
| Alcohol | fl. oz. | 10 |
| Peppermint water sufficient to make | fl. oz. | 32 |

Koller recommends odontine as a very agreeable and elegant article and gives these directions for its preparation: 125 grams of quillaja bark and three and one-half grams of persio are digested for several days in a closed vessel with a mixture of equal volumes of water and alcohol. To this liquid, measuring about one liter, is added a mixture of heliotropin, 0.13 gram, peppermint oil, twenty drops, and oil of aniseed, ten drops, dissolved in 30 c.c. of alcohol. After standing several days in a filled, stoppered bottle, put in a moderately warm place, the solution is filtered, if necessary, mixed with 500 grams of glycerin, and filled into bottles holding two to three ounces.

Another popular preparation is Eau de Botot prepared according to a variety of recipes.

Koller highly recommends this method: Lemon rind 100 grams, cloves 100 grams, horseradish 100 grams, rose leaves 100 grams, and soap powder 100 grams are finely ground or pounded, suffused with eight liters of alcohol, and then distilled. In about three weeks the preparation is scented with 25 grams of cassia oil and 160 of peppermint oil, and filled into bottles.

Foamy mint consists of:

| | | |
|---|---|---|
| Castile soap | | 3 ounces. |
| Glycerin | | 5 ounces. |
| Water | | 20 ounces. |
| Alcohol | | 30 ounces. |
| Oil of peppermint, Oil of wintergreen, Oil of orange, Oil of anise, Oil of cassia | of each | 1 drachm. |

The soap is beaten up with the glycerin and water in a mortar. The oils dissolved in the alcohol are poured on the soap solution. The preparation may be tinted with carmine.

Another formula is:

| | | |
|---|---|---|
| Thymol | gr. | 30 |
| Oil of wintergreen | fl. dr. | 1 |
| Oil of peppermint | fl. dr. | 1 |
| Compound tincture of cardamon | fl. oz. | 2½ |
| Glycerin | fl. oz. | 2 |
| Sandalwood | av. oz. | 1 |
| Tincture of quillaja | fl. dr. | 2 |
| Alcohol | fl. oz. | 13 |
| Water sufficient to make | fl. oz. | 32 |

Soapbark may be used, as in:

| | | |
|---|---|---|
| Soapbark, powder | av. oz. | 4 |
| Glycerin | fl. oz. | 3 |
| Diluted alcohol | fl. oz. | 30 |
| Oil of wintergreen | drops | 20 |
| Oil of peppermint | drops | 20 |

Soap is often employed in these preparations:

| | | |
|---|---|---|
| Castile soap, white | av. oz. | ½ |
| Myrrh, bruised | av. oz. | 1½ |
| Spirit of lemon | dr. | 2 |
| Oil of peppermint | drops | 15 |
| Oil of star anise | drops | 15 |
| Oil of wintergreen | drops | 5 |
| Glycerin | fl. oz. | 2 |
| Acetic ether | fl. dr. | 2 |
| Alcohol | fl. oz. | 24 |
| Water | fl. oz. | 8 |
| Alkanin or alkanet sufficient to tint. | | |

MOUTH WASHES are used to cleanse, purify and deodorize the mouth, and often to cleanse the teeth.

These preparations are generally diluted with water for use, one teaspoonful to a cup of water. Antiseptic and flavoring elements are used and generally an astringent like kino, tannic acid, oak bark, or rhatany. Coloring agents are frequently employed.

An extremely simple formula is:

| | | |
|---|---|---|
| Potassium permanganate | gr. | 30 |
| Distilled water | fl. oz. | 4 |

One teaspoonful to a tumblerful of water.

Huchard gives this formula:

| | |
|---|---|
| Crystallized boric acid | 4.0 grams. |
| Eucalyptol | 1.0 gram. |
| Salol | 2.0 grams. |
| Menthol | 0.25grams. |
| Thymol | 0.1 gram. |
| Alcohol | 100.0 grams. |

This may be tinted and scented according to taste.

A preparation containing kino is:

| | | |
|---|---|---|
| Kino, powder | av. oz. | 5 |
| Tincture of benzoin | fl. dr. | 1 |
| Tincture of tolu | fl. dr. | 1 |
| Tincture of vanilla | fl. dr. | ½ |
| Oil of peppermint | fl. dr. | 1 |
| Oil of anise | fl. dr. | ½ |
| Oil of cinnamon | fl. dr. | ½ |
| Alcohol | fl. oz. | 32 |

Mix, macerate for a week with occasional stirring, and filter.

A preparation that is antiseptic, stimulant, astringent, germicidal, and deodorant, contains twenty-five per cent. of grain alcohol. It consists of zinc iodide, zinc chloride, formaldehyde, resorcin, boric acid, thymol, benzoic acid, eucalyptol, grain alcohol, glycerin, water, and vegetable flavoring. This preparation is diluted with four or five parts of water.

A mouth wash used in Riggs' disease, contains: Iodine, zinc chloride, formaldehyde, resorcin, boric acid, potassium iodide, tannin, thymol, benzoic acid, eucalyptol, grain alcohol, glycerin, water, and vegetable flavoring.

In case of pyorrhea, dilute Lugol's solution, one part to three of water, is recommended on account of its mild antiseptic and astringent action. In addition to these advantages, it has a more important though indirect action. By staining the tartar and other deposits on the teeth, it stimulates the patients to consult the dentist for the proper cleaning and scaling of the teeth.

"While specific symptoms of infectious morbidity always show, Riggs' disease, in the form of pyorrhea alveolaris, is constantly escaped by the habitually hygienic mouth."

The keynote of sound teeth and a wholesome mouth is Prophylaxis.

For many years the alkaline treatment for diseases of the teeth and mouth has been undisputed. Of late years, however, this treatment has not gone without challenge. Although we must accept as a chemical fact the destruction of acids by alkalies, there are other conditions that must be recognized. In the continuous use of alkalies in the mouth we forget one of the links of a vicious circle. For acid-forming bacteria, one of the factors causing dental caries, thrive well only in a neutral or an alkaline medium. Consequently, when an alkali is used in the mouth, we are using the very means to preserve the lives of the bacteria that form acids. The two factors chiefly concerned in the destruction of teeth are the carbohydrates—principally sugars—and bacteria. By bacteria, sugars are split into lactic acid, and lactic acid is the leading cause of tooth destruction. In addition to lactic acid, bacteria, heat, and moisture, are necessary to complete the process of dental destruction.

In combating dental caries, the temporary neutralization of acids in the mouth should not be the burden of our prophylactic efforts. Rather must the acid-producing organisms themselves be destroyed. It is interesting to note in this connection that herbivorous animals in spite of their alkaline saliva, suffer from dental caries. The resistance of normal tissues to the invading microbe offers the chief barrier to the inroads of infection. The oral tissues are highly vascular and their slight stimulation by means of proper antiseptics of mild and harmless acidity increases the inflow of alkaline blood and tones up the resistance of the tissues. Besides, acids are direct poisons to protoplasm, and since bacteria are unicellular protoplasmic organisms, they are destroyed by the acid radical. This acid radical, however, must be such as to have no deleterious effect upon the enamel of the teeth.

From a pharmacological point of view, the action of alkalies does not depend upon their metal ion, as sodium or potassium, but upon the hydroxyl ion; and the hydroxyl ions, although cauterant, do not exert any marked antibacterial action.

Alkaline mouth washes are solvents of viscid tenacious mucoid products, while acids precipitate these proteins. But cleansing the mouth will mechanically remove freshly formed precipitates.

The arguments so long advanced in favor of alkaline mouth washes are rather theoretical than practical. More to be preferred are preparations which by their slight acidity stimulate the resistance of the tissues and poison bacteria.

Gies, in his studies along this line, refers to Pickerill's six years' observation of New Zealand savages who are distinguished for their fine, white, well-formed teeth which are singularly free from caries. These people use none of the alkaline dentifrices that civilized races have so long been taught are essential. Gies declares that those who sell these articles, and not physiologists, are responsible for this teaching.

Both Gies and Pickerill advocate the use of the acids in ordinary fruit juices as the ideal tooth wash. Unlike mineral acids, these juices do not readily attack the enamel. On the other hand, fruit juice, that of the orange for example, renders non-adhesive the viscid, slippery film on the teeth in which lies the chief danger of decay. The application of such acid mixtures followed by immediate flushing with water is most cleansing, while the ordinary alkaline dentifrices "make mucin films more viscid and slippery." According to this theory, meals are well terminated with foods having an acid reaction. Besides removing the destructive mucilaginous covering of the teeth, these fruit juices stimulate the flow of saliva which itself exerts a distinct antiseptic effect. In accordance with this propaganda, diluted fruit vinegar is advised as a tooth wash. Gies believes it to be more effective than the most elaborate dentifrice.

The importance of definite knowledge concerning effective and harmless dentifrices may to a certain extent be gauged by the following facts.

An unclean mouth acts as a hot bed of infection for all food, no matter how clean may be the latter. From an unhygienic mouth, millions of bacteria are passed on to the stomach and intestines, and the individual instead of profiting by the products of a normal digestion will necessarily suffer the effects of bacterial poisoning.

The life insurance companies have of late years evinced such interest in dental examination and mouth hygiene for insurance in their conservation departments as to indicate that the condition of the teeth and mouth will before long receive their definite attention.

It is believed that eighty per cent. of all dental operations can be prevented by prophylaxis.

Dentistry is coming to be the science of healthful living and like its sister science medicine it is turning more and more to the field of Prophylaxis.

EMMA E. WALKER.

**Dentition.**—Dentition may be described as the process and growth of teeth in the jaw. The teeth vary greatly in shape, number, and arrangement in different animals, and groups of animals, and furnish important data for purposes of classification. In some fishes the teeth are continuous, over the edges of the jaws, with the scales of the surface of the body, and should be regarded as modified scales which have migrated into the mouth. In other fish the teeth are exceedingly numerous and every bone bounding the mouth bears teeth. In the amphibia and reptilia the teeth are fewer and occasionally absent, but there is the greatest variety in their number and arrangement.

Existing birds are toothless, but originally they had teeth of a reptilian character. In all these lower vertebrates the teeth are similar in character, that is they are not divided into varieties, such as incisor, canine, and molar, and in these animals also there is usually a continuous succession of teeth so that when one is lost another from behind takes its place.

In the mammalia the different groups of teeth present in man are found and these animals are characterized with some exceptions by having a heterodont as opposed to a homodont dentition. In the mammals too the continuous succession of teeth is reduced to diphyodont dentition which means that there is only one relay of teeth to replace the first set. In a few mammalia, notably in the tooth whales, there is no succession at all, the first teeth remaining throughout life. Man like most of the other mammals referred to, is provided with two sets of teeth which make their appearance in different periods of life. The first set called the temporary, deciduous, or milk teeth, are twenty in number: four incisors, two canine, and four molars in each jaw. The second set, called the permanent, continue until old age and are thirty-two in number: four incisors, two canines, four bicuspids, and six molars in each jaw. Each tooth consists of three portions, the crown or body protruding above the gum, the root in the alveolus, and the neck, the constricted portion between the two.

Development.—The development of the *temporary teeth* begins in an early period of fetal life. About the seventh week, a longitudinal depression or groove appears in the margin of the jaw; the projecting margins of the groove are called the dental ridges. These are made up largely of a collection of epithelial cells. These cells increase rapidly in number and penetrate the underlying mesodermal tissue in various places or pits along the dental groove. The soft connective tissue beneath these epithelial projections grows upward, becomes vascular and is received in dimples on their under surface. By continued growth it pushes up farther into these masses of epithelium which are to form the enamel of the tooth. This connective tissue capped by the enamel organ is gradually transformed into dentine. At the same time soft embryonic tissue grows up in the form of ridges on each side of the rudimentary tooth cutting off the enamel organ from the surface and completely surrounding each tooth in a dental sac. In this manner we have briefly accounted for the formation of the enamel organs derived from epithelium and surmounting the central mesoblastic portions which are transformed into dentine and supplied with nerves and blood-vessels, each embryo tooth fitting into a bony socket in the jaw.

The tooth itself until cut is surrounded by a dental sac. The germs of the milk teeth appear in the following weeks of fetal life:

The seventh week the first molar in the upper jaw; eighth week canine, ninth week, two incisors, tenth week, second molar.

The teeth of the lower jaw develop a little later than those of the upper. The second molar not being formed before the eleventh week.

The *permanent teeth* are of two varieties, those which take the place of milk teeth and the superadded permanent teeth. The former are derived from a budding off posteriorly of a part of the epithelial cells forming the enamel organ of the milk teeth. As these projections recede into the substance of the gum they meet the papillæ in the same manner as was the case in the temporary teeth and the apex of the papilla undergoes a similar change into dentine in the manner already described.

Each permanent tooth likewise is surrounded by a dental sac which adheres to the sac of the temporary tooth. The three superadded permanent teeth arise from successive extensions backward of the enamel germ from the tooth immediately preceding. Calcification of the permanent teeth commences a little before birth and proceeds in the following order in the upper jaw (the lower jaw is a little earlier): first molar fifth or sixth month; central incisor, seventh month; lateral incisors and canine eighth or ninth month; bicuspids second year; second molar fifth or sixth year; third molar (wisdom tooth) about the twelfth year.

Eruption.—When the calcification of the tooth is sufficient to enable it to bear the pressure to which it will be subjected, the tooth makes its way through the gum because of the increasing size and growth of the root. The overlying gum is absorbed by the pressure of the crown of the tooth against it. At the same time the septa between the dental sacs which are at first fibrous in structure, ossify and constitute the alveoli which firmly embrace the necks of the teeth and afford them solid support.

At birth the twenty embryo teeth are so inclosed that nothing but the smooth mucous membrane is apparent in the gums above. The teeth gradually grow through the points of least resistance outward and the crown appears on the edge of the gum. The various teeth come through the gums at times corresponding to the calcification of their roots. This process usually takes place in groups with considerable regularity, although many marked variations to be described later occur.

The average dentition of the temporary teeth occurs about as follows:

Sixth to eighth month, two middle lower incisors.

Eighth to tenth month, four upper incisors.

Twelfth to fourteenth month, two lateral lower incisors and four first molars.

Eighteenth to twentieth month, four canines.

Twenty-eighth to thirty-second month, four second molars.

For approximately four years the temporary or milk teeth remain intact. About the sixth year the second set of teeth begins to appear. The first four teeth of the second dentition are usually called the "six year molars." They do not replace any of the temporary teeth, but appear back of and next to the second molars. At this time the process of absorption of the roots of the milk teeth commences. There is an increased vascular supply in the tissue surrounding the roots—large giant cells similar to the osteoclasts of bone tissue are actively concerned in the absorption of the roots. The alveoli of the milk teeth become enlarged, but little is left except the enameled crowns, and when the teeth of the first set are pushed out to make way for the advancing permanent teeth without any caries and without pain.

The order of the second dentition is also subject to considerable variation depending upon the resistance of the milk teeth, and the rapidity of growth of the permanent set.

The eruption of the permanent teeth can always be hastened by the forceful removal of the corresponding milk teeth in front.

The average time of the second dentition is as follows:

6 to 7 years, 4 first molars
7 to 8 years, 4 middle incisors
8 to 9 years, 4 lateral incisors
9 to 10 years, 4 first bicuspids
10 to 11 years, 4 second bicuspids
11 to 12 years, 4 canines
12 to 13 years, 4 second molars
17 to 25 years, 4 third molars or wisdom teeth.

The reasons for the eruption of teeth are unknown. The process is a physiological one and bound up with the general growth of the body and the development of the organs. It has been recently suggested by Josefson that there is direct connection between dentition and the so-called internal secretions, and that a lowered production of these is followed by irregular or by delayed dentition.

Abnormalities of Dentition.—As can easily be imagined the eruption of both temporary and permanent teeth is subject to many variations. Dentition is retarded in rachitic infants and in other chronic conditions associated with pronounced malnutrition. It is delayed also in mentally defective children. On the other hand, the protrusion of teeth may be premature, not infrequently one or two teeth may be present at birth and the remainder of the dentition proceed normally at the usual time. This condition may be connected with premature ossification of the bony system in general or it may be due to a periostitis of the maxillary bones occurring during fetal life.

Certain historical characters, notably Marcus Aurelius, Richard III., Mirabeau, and Louis XIV, are said to have been born with teeth. In rare instances there has been an absence of all teeth due probably to lack of formation of the elementary dental follicles. Symmetrical absence of corresponding teeth has also been reported. Either the temporary or the permanent dentition may be defective without affecting the other. Supernumerary teeth, either deciduous or permanent, have been frequently observed. Their development may be due to abnormal segmentation of the dental follicles. These teeth are usually in abnormal positions, often near the first incisors, and may produce injury to the tongue; therefore, when recognized, they should be promptly removed.

Not only are there many anomalies in respect to the time of eruption, the number, position, and size of the teeth, but the latter may also present very wide variations in their structure. The same chronic diseases, notably rickets and syphilis, which retard the eruption of teeth may also render them less firm and of unnatural thickness and prone to decay. Acute diseases, particularly the exanthemata may also produce pathological changes in the permanent teeth.

The most striking dental abnormality as the result of disease is the so-called Hutchinsonian teeth in congenital lues. This change affects particularly the permanent median upper incisors which are unusually short with rounded corners and having a broad vertical notch at the bottom of which the dentine is exposed. Some other writers believe the deciduous teeth are similarly affected in syphilis. It must be emphasized however that the absence of this appearance does not exclude the existence of the disease. Recent investigation tends to cast some doubt upon the *pathognomonic* significance of the so-called Hutchinsonian teeth, similar defects being frequently found in nonluetic children suffering from other diseases. In syphilis the enamel seems to be particularly soft and irregular and the *Spirochæta pallida* has been demonstrated in dentine and pulp.

There is considerable evidence for the assumption that the teeth of children nursed at the breast present fewer abnormalities than those of artificially fed infants. This view has received support in the large proportion of defective teeth found in children suffering from *tetany* which is best corrected by mother's milk. Various anomalies and diseased conditions of the maxillary bones are associated with irregular or defective dentition. This is true in hare lip, cleft palate, in overlapping of either the upper or lower jaw, which prevents the normal approximation of the teeth. Dentition may be altered by changes in the outlines of the mouth induced by functional disturbances, such as sucking of the thumb or by mouth breathing. In the former condition the outlines of the dental arch may be so bowed that the front teeth do not approximate and are often everted.

In mouth breathing the high position of the hard palate and the narrow angular dental arch interferes with normal dentition. It is perhaps unnecessary to more than refer to other congenital malformations such as maxillary cysts or tumors of various kinds which may affect the jaw and likewise interfere with the normal eruption of the teeth.

Disorders of Dentition.—Dentition has assumed a position of varying importance in connection with the diseases of infancy. Physicians among the ancients and in the middle ages, and indeed until the eighteenth century, attributed many ailments to teething. Hippocrates ascribed fever, convulsions, and diarrhea to the cutting of the permanent teeth. The list of diseases ascribed to teething in the sixteenth and seventeenth centuries includes among others chorea, epilepsy, deafness, paralysis, various affections of the brain, and also measles, smallpox, and purulent inflammations of the eye. Nearly all skin diseases among infants were associated with dentition as were also gastrointestinal disorders with diarrhea; bronchitis and bronchopneumonia were often ascribed to the same cause.

Lennert in the seventeenth century asserted that "parents could not enjoy their children until they had cut their permanent teeth." In the middle of the nineteenth century, seven per cent. of the deaths reported officially in London under the age of three years were attributed to dentition. The decline in the prominence of this physiological process as a cause of death is illustrated in Berlin statistics. In 1877 1.4 per cent. of all infant deaths were ascribed to dentition, where as at present this cause of death has practically disappeared. This is as it should be, for it is difficult to believe that dentition, which is a normal physiological process corresponding to menstruation, or the changes of the climacteric, should any more than these be a direct cause of death, and yet the public at large, even the educated part of the community, still regard teething and worms as the twin scapegoats to which to ascribe most of the diseases of infancy. Every physician has had the experience described by Jacobi of having brought to him a thin, anemic infant with sunken eyes and drawn facies, *i.e.* one in extreme malnutrition and has been assured by the mother that the child is suffering from teething. This diagnosis is still made by many of the medical profession.

The first important remonstrance against the generally accepted dogma of dentition was made in 1797 by Wichmann who declared that inadequate diagnosis of the diseases of children affords the greatest support to the dentition theory. His observations made little impression upon the profession and the repertoire of disorders produced by teething and accepted by the most prominent physicians embraced nearly all the known diseases. The most important examinations into the facts were made by Viennese pediatrists, Von Hirschman, Politzer, and especially by Kassowitz, who in his investigation on rickets in infants gave special attention to the process of dentition and who showed upon what feeble support and popular fallacy the whole subject rested.

He asserted that he never had been called upon to treat a case of difficult dentition.

It is of the utmost importance, therefore, to weigh the evidence for and against the production of disease by dentition and to confine the evil consequences, if such there be, to those symptoms which can be definitely found. Let us consider how little basis in fact there is for ascribing to dentition some of the ills most frequently associated with it in the minds of the laity.

*Drooling.*—This cannot be proven to be the result of teething. It occurs often long before teeth appear and may stop at twelve months when the first dentition is but half over. On the other hand it often persists for years in mentally defective children, irrespective of teething.

*Sucking of Fingers and Thumbs.*—These habits also occur at any time in infancy and may persist long after the teeth are cut.

*Inflammatory conditions* of the mouth have been for centuries ascribed to teething when more careful investigation shows them to be due to bacteria, or fungii, or other infection, such as thrush.

*Tooth Cough.*—There is no proof whatever that dentition directly produces cough. No certain case of this condition has been reported. The so-called tooth cough practically disappears in summer and occurs in the winter months when irritations of the throat and bronchial mucous membranes are common. Usually, careful examination will discover rhinitis, adenoids, or bronchitis to explain the cough.

*Diarrhea.*—That diarrhea may be due to teething is one of the most firmly grounded of the popular beliefs. There is no uniformity in the description of this form of diarrhea. It occurs for the most part in hot weather and frequently affects babies of the earliest age before any teeth appear. Well-nourished children are comparatively seldom affected and still less often do cases of diarrhea occur among breast-fed babies. Furthermore, the condition is cured by change of diet and other procedures that are helpful in treating diarrhea in general.

The popular fallacy that it is dangerous to check diarrhea during teething may be explained as Kassowitz has suggested by the fact that tuberculous meningitis, often associated with constipation, may have developed in certain cases.

*Convulsions.*—It is unquestionably true that convulsions are most frequent during the time of dentition, that is from three months to three years, but there is no evidence whatever for ascribing infantile convulsions directly to teething. In nearly every instance another cause can be found. Eclampsia in infancy is of course most common in spasmophilic children. This condition is usually promptly cured by a change of diet and irrespective of the condition of dentition. Moreover, the characteristic electrical reactions of tetany are absent. The response of spasmophilic infants to galvanic currents is not affected by cutting the teeth.

*Skin Eruption.*—Skin eruptions of various kinds are often attributed to teething. This apparently is mere coincidence as these disorders are more common in children after their first dentition than before.

*Dentition Fever.*—This is the symptom which most tenaciously clings to dentition. A fever in infancy for which no cause can be found is usually attributed to teething. The number of cases has markedly diminished as diagnostic skill has increased. Many cases which in the past would have been called dentition fever are now known to be due to otitis, tuberculosis, cystitis, pneumonia, etc.

Probably few modern physicians unfamiliar with the traditions of the past would make a diagnosis of dentition disease. The persistence of the designation, "dentition fever," is due for the most part to a psychological reason. People are more alarmed about an unknown ailment than one with a name. Parents are willing to wait for the subsidence of serious symptoms if a tooth is about to be cut. The synchronous appearance of illness and a tooth supports the long-standing hypothesis. A child teeths for a *quarter of the time* from six months to about two and a half years, at which period it is singularly susceptible to many disorders.

The prominence of dentition in the pathology of infancy arose in an age without percussion, auscultation, and thermometers, at a time when pathological anatomy and bacteriology were unknown, and yet there are few careful clinical observers who are not convinced that a certain proportion of children manifest definite symptoms of local irritation during the cutting of one or all of their teeth. In many cases the gum near the tooth is swollen and red, irritated or tender, the child is fretful and salivation seems increased. There is some evidence too that there may be pain in the ear with congestion of the tympanum, possibly produced through the close connection between the inferior dental nerve and the nerves governing the blood supply of the drum membrane.

Dunn has reported an instance of fever apparently due to reflex irritation, which subsided a short time after each tooth appeared. There seems to be little doubt that the appetite and the digestive capacity become less vigorous during the time the gums are troublesome in a teething baby but there is no evidence whatever to indicate that this is more often true than would be the case when the child is suffering from other irritations, such as stomatitis, from various causes.

Disorders of Second Dentition.—It is remarkable that if the cutting of teeth is so disturbing a process, its discomforts should be so largely confined to the eruption of the milk teeth. Very rarely does one hear older children complain of pain during the second dentition and yet the permanent teeth have greater obstacles to overcome in their eruption than have the temporary teeth in penetrating the soft gum. The cutting of the wisdom teeth is sometimes painful because the space for these teeth is often insufficient. Disorders therefore ascribed to the second dentition are almost entirely local in character.

Therapeutics.—Many and various crude therapeutic measures have been suggested to mitigate the many dangers of teething, brains of rabbits, blood from a cock's comb, and similar remedies have been used to rub on the gums to aid dentition. Various amulets and necklaces are still placed on infants for the same purpose. Bread from the wedding feast of a newly married couple was held in Europe to be of signal value, as was also a mass of sprouts cut at 12 o'clock on Good Friday! Scarification of the gums or lancing was brought into general vogue by Ambroise Paré and practised extensively in England by John Hunter who sometimes scarified ten times over the same tooth. The most enthusiastic eulogizer of scarification was Marshall Hall of England who asserted that "it was better to scarify the gums a hundred times unnecessarily than to permit one fit of convulsions as the result of neglect of this operation."

From what has been said of the progress of our knowledge of dentition and its consequences, it can be rightly inferred that its treatment among the best informed practitioners has become exceedingly limited. It is quite possible that very exceptionally a bulging reddened gum in a restless, sleepless child may be properly lanced. This must be done only when the eruption of the tooth is imminent, as the formation of a scar over a tooth not ready to be cut makes the process even more difficult. The most intelligent therapeutics during dentition results from a knowledge that when a child is constantly irritated by the nagging pain its powers of resistance are certainly lowered and its digestive capacity lessened. It is wise therefore at this time to reduce the amount

of food given and supply abundant water and to lengthen the feeding intervals. At this time special care should be given to the child's clothing and it should be especially guarded from all untoward circumstances. It should not be exposed in inclement weather; in this way affections of the throat and bronchial tubes, to which it may be a little more susceptible during teething may be avoided. Local applications to the swollen gums are rarely necessary. Cool peppermint water applied to the gums on soft cotton is sometimes grateful. Most exceptionally it may be wise to allay the pain of a swollen gum by a weak application of cocaine. When the child is unusually restless and irritable a small dose of a sedative such as bromide or chloral before bedtime is indicated. J. H. Mason Knox, Jr.

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**Denver.**—The city of Denver, Colorado, latitude 39° 45′ N., longitude 105° W., lies upon the South Platte River, thirty-five miles from the main range of the Rocky Mountains, and fourteen miles east from their outlying foothills—on the western limit of the great plains which stretch away to the Missouri River. Its elevation above sea level is 5,290 feet.

Besides being the capital and chief business city of Colorado, Denver is the most important railroad and distributing center for the entire rocky mountain region. The city is built upon both sides of the river, but chiefly on the right bank of the stream which, flowing north, bends in the middle of the city to the northeast. The westerly bank rises in a sharp slope about one hundred and fifty feet, while on the east this elevation is not reached till about two miles from the river, the rise being gradual and easy. The immediate river valley is given over to industrial occupation, the residence districts lying to the east, south and west. The streets are wide, and in the business portion of the city paved with asphalt, as are three of the main avenues into the residence district, where the streets are bordered by parked sidewalks shaded by trees. There are two hundred and thirty miles of electric street railway reaching to every part of the city and into the surrounding country. The buildings are substantial and throughout the city built wholly of brick and stone. The residence districts are noticeably those of homes, there being very few blocks or tenements. The public-school system is excellent and progressive, and the city is well provided with theaters and churches of all denominations. There is a good public library of 250,000 volumes; and four branch libraries. The Medical Society of the city possesses a medical library of over 11,000 volumes. There are six hospitals: The county hospital with 500 beds; St. Lukes (Protestant Episcopal) 130; St. Joseph's, St. Anthony's and the Mercy Hospital (all Roman Catholic) with 225, 170, and 125 beds respectively—and a Children's Hospital of 35 beds.

There are also several sanatoria for tuberculosis. The National Jewish Hospital for Consumptives; The Jewish Consumptive Relief Hospital; The Swedish National Sanatorium—all charitable and well maintained. The Agnes Memorial Sanatorium and the "Home" are well equipped private institutions for the reception of invalids with tuberculosis. Hotel accommodations are numerous and of a high order. The public parks have an area of 1,238 acres. There is a system of public sewers which empty into the Platte River below the city. The public water is supplied by a private corporation and is of excellent quality and ample supply.

The population is about 200,000. The health of the community is good, there being a notable absence of diarrheal and infectious diseases, other than tuberculosis contracted elsewhere.

The early reputation of Denver as a health resort, especially for those suffering from pulmonary tuberculosis, has been steadily maintained, and while the rapid growth of the city and increase in industries of late years have necessarily rendered the heart of the city unsuited for an invalid, the outlying residence districts are free from contamination, and the city still holds its place among the health resorts of the Rocky Mountains.

*Climatically,* Denver should be classed as a high-altitude resort, with a dry, *cool* climate of considerable extremes of temperature and abundant strong sunshine.

*Altitude.*—Denver is one mile above sea level, and has a mean barometric pressure of 24.74 inches. It is not, however, in the mountains, but lies upon the open plains fifteen miles east from the foothills. This open situation frees it from the diurnal up-and-down draught of a mountain valley, and the long day of sunshine is unbroken by the shadows of surrounding peaks. This distinct advantage over most high-altitude resorts has a very practical relation to the daily life of an invalid. In Davos-Platz, the most noted of the Swiss high-altitude resorts, which lies at the same elevation as Denver, but in a valley protected by surrounding mountain heights, the sun does not rise on January 1 till 10:03 A.M., and sets at 3 P.M. In Denver, on January 1, the sun rises at 7:19 A.M., and does not set till 4:49 P.M., giving nine hours and a half of daylight. Speaking of Davos, Dr. Wise says: "An additional hour's sunlight during the short days of December and January is an inconceivable delight." In Denver the eastern horizon is low and level and offers no delay to the warm cheering of daylight. On December 1 the sun rises at 7 A.M., on January 1 at 7:19, and on February 1 at 7:07. Nor is the day shortened in the afternoon, the fifteen miles "set-out" from the mountains distinctly lengthening the day.

*Sunshine.*—A reference to Table I., column F, will show the total number of hours of possible sunshine at Denver during each month of the year. Even in the months of shortest days, December and January, there are over nine hours and a half of possible sunshine each day.

The percentage of the total possible sunshine actually realized is high, being in the yearly average sixty-eight per cent. as shown by the records of the Weather Bureau over the last twenty-two years. The annual average ranges from seventy-five to sixty-one per cent. This large proportion of actual sunshine is quite evenly distributed throughout the year, as will be seen by Table I., columns S, T, and U, where the mean total percentage of sunshine is shown, together with the highest and lowest monthly record during the period of observation. The lowest record was in May, 1892, when the sunshine record was only forty-two per cent. and the precipitation was 8.57 inches. A reference to Table I., columns M and N, shows that this is equally exceptional. In the other years of observation the rainfall and sunshine records have fallen within the line of averages.

During the winter months from November to March the average percentage of sunshine obtained in Denver is 67.6 with a minimum record of 48.8, while the average obtained in Philadelphia for the same months is 37.

TABLE I.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean barometer in 38 years. | Mean temperature (deg. F.) in 40 years. | Highest mean temperature (deg. F.) in 40 years. | Lowest mean temperature (deg. F.) in 40 years. | Average of mean maximum temperature (deg. F.) in 38 years. | Average of mean minimum temperature (deg. F.) in 38 years. | Average highest temperature (deg. F.) in 41 years. | Average lowest temperature (deg. F.) in 41 years. | Absolute highest temperature (deg. F.) in 41 years. | Absolute lowest temperature (deg. F.) in 41 years. | Mean relative humidity in 25 years. Per cent. | Mean dew point (deg. F.), 8 years. | Average total precipitation in inches, 40 years. | Highest total precipitation in inches, 40 years. | Lowest total precipitation in inches, 40 years. | Number of times above the average in 40 years. | Number of times below the average in 40 years. | Total number of hours of possible sunshine. | Mean percentage of possible sunshine actually obtained, 22 years | Highest percentage for the month in 22 years. | Lowest percentage for the month in 22 years. | Average number of clear days in 39 years. | Average number of partly cloudy days in 39 years. | Average number of cloudy days in 39 years. | Mean total movement of wind for the month. Average for 38 years. Miles. | Average hourly velocity. Miles. Average for 39 years. | Mean maximum velocity maintained for a 1-hr period between 8 A. M. and 8 P. M. Average for 40 years. Miles. |
| January | 24.66 | 31.0 | 38 | 18 | 42.7 | 17.0 | 63.1 | −8.4 | 76 | −29 | 55 | 17.0 | 0.46 | 2.35 | 0.04 | 14 | 25 | 301 | 69 | 87 | 47 | 14.6 | 12.3 | 4.1 | 5549.6 | 7.5 | 10.0 |
| February | 24.64 | 32.9 | 40 | 18 | 44.5 | 19.6 | 63.6 | −3.1 | 77 | −22 | 56 | 15.6 | 0.49 | 1.35 | 0.04 | 16 | 24 | 300 | 68 | 83 | 56 | 12.2 | 11.7 | 4.4 | 5072.7 | 7.5 | 10.3 |
| March | 24.62 | 40.8 | 50 | 30 | 52.0 | 26.0 | 71.5 | −7.0 | 82 | −11 | 59 | 21.0 | 1.0 | 3.10 | 0.11 | 13 | 26 | 371 | 66 | 87 | 42 | 11.5 | 12.9 | 6.6 | 6025.8 | 8.1 | 11.8 |
| April | 24.65 | 48.9 | 54 | 41 | 60.0 | 34.9 | 78.2 | 18.0 | 86 | 4 | 50 | 25.8 | 2.07 | 8.24 | 0.05 | 18 | 22 | 399 | 67 | 84 | 50 | 9.9 | 12.9 | 7.2 | 6003.0 | 8.3 | 11.9 |
| May | 24.66 | 56.6 | 62 | 50 | 69.2 | 43.8 | 85.1 | 31.3 | 92 | 19 | 54 | 33.3 | 2.49 | 8.57 | 0.09 | 20 | 20 | 447 | 60 | 79 | 42 | 8.4 | 15.4 | 7.2 | 5607.4 | 7.5 | 11.1 |
| June | 24.71 | 66.5 | 72 | 62 | 80.3 | 52.4 | 93.4 | 41.8 | 99 | 36 | 50 | 41.8 | 1.42 | 4.96 | T. | 19 | 21 | 449 | 68 | 82 | 45 | 12.2 | 13.9 | 3.9 | 5188.8 | 7.2 | 11.0 |
| July | 24.79 | 72.0 | 77 | 67 | 85.8 | 58.3 | 96.2 | 49.6 | 102 | 42 | 48 | 48.2 | 1.74 | 4.23 | 0.01 | 17 | 23 | 455 | 67 | 83 | 56 | 11.2 | 15.7 | 4.1 | 5043.5 | 6.8 | 10.1 |
| August | 24.80 | 71.1 | 75 | 68 | 84.9 | 57.3 | 95.1 | 48.4 | 105 | 40 | 50 | 47.8 | 1.38 | 3.19 | 0.05 | 19 | 20 | 425 | 67 | 77 | 58 | 10.8 | 15.8 | 4.5 | 4799.0 | 6.4 | 9.5 |
| September | 24.78 | 62.8 | 66 | 60 | 77.2 | 48.6 | 90.2 | 34.9 | 97 | 21 | 48 | 40.5 | 0.97 | 3.78 | T. | 15 | 24 | 374 | 72 | 89 | 63 | 15.7 | 10.6 | 3.5 | 4710.0 | 6.5 | 9.0 |
| October | 24.76 | 51.1 | 56 | 46 | 65.1 | 37.4 | 81.9 | 22.1 | 90 | 1 | 50 | 29.1 | 0.92 | 3.92 | 0.12 | 14 | 26 | 345 | 74 | 89 | 62 | 16.0 | 10.9 | 4.3 | 5112.5 | 6.9 | 8.8 |
| November | 24.73 | 39.5 | 46 | 22 | 52.4 | 26.1 | 71.7 | 6.2 | 77 | −18 | 53 | 22.2 | 0.56 | 1.98 | T. | 15 | 25 | 300 | 68 | 81 | 45 | 14.5 | 10.8 | 4.6 | 5080.8 | 7.1 | 9.2 |
| December | 24.70 | 32.4 | 40 | 21 | 45.0 | 20.0 | 65.1 | −2.8 | 74 | −25 | 54 | 16.1 | 0.60 | 2.32 | T. | 19 | 21 | 292 | 67 | 85 | 52 | 14.9 | 12.4 | 3.7 | 5491.4 | 7.1 | 9.6 |

The average number of wholly cloudy days in a year in Denver is but 58, while 155 are partly cloudy, and 152 are wholly clear from sunrise to sunset. The 155 days recorded as partly cloudy must not be considered unsuited for outdoor life, for the cloudiness is often light and even a grateful change from the intense brilliancy of a cloudless day. Table I., columns V, W, and X, shows the general evenness of the distribution throughout the year with the slight increase in the partly cloudy days in the spring months due to the occasional showers during that period, as will be seen by comparing the same months in column M.

*Humidity.*—The relative humidity at Denver is very low, being but 62.3 per cent. at 6 A. M., and 40.4 per cent. at 6 P. M., with a yearly mean of 52 per cent., varying in monthly means from a maximum in twenty-five years' record of seventy-three in December to a minimum of thirty-one in October. The absolute humidity is also very slight, being but a fraction over two grains of moisture to the cubic foot. This constant dryness of the air has a decided effect upon the sensible temperature of the air, rendering the recorded heat of the summer months not comparable to similar figures in cities upon the seaboard. Evaporation from the skin is rapid in summer, leaving the body dry and cool, while in winter the same dryness of the air makes the low readings of the thermometer less realized. It affects, too, the intensity of the sunlight, causing a variation between the air and solar temperatures of from 40° to 60° throughout the year.

*Temperature.*—The climate at Denver is cool. The mean annual temperature is 50.1° F., the mean for January being 31° and for July 72°. The range between the highest mean temperature of any month and the lowest mean for the same month is not great, and is remarkably even throughout the year, as shown in Table I., columns C and D. The extremes of temperature during the year appear great, but the average variation of the monthly mean maxima and mean minima seen in Table I., columns E and F., is not great when the balancing effects of dry air and sunshine are considered. Columns E and F represent the average for thirty-eight years of the monthly mean maximum or minimum temperatures of all the days. Columns G and H, on the other hand, represent the average for forty-one years of the single highest or lowest temperatures recorded in the month; while columns I and J give the absolute maximum and minimum temperatures during the entire period of observation.

In comparing these three sets of columns with the mean for the month during the whole-period column, the influence of single high or low readings is discerned. For instance, in the month of January, while a maximum day temperature of 76° has been recorded and a reading of −29° may occur, yet the experience of forty-one years shows that the average highest temperature will be but 63.1 and the average lowest only −8.4 while the average during thirty-eight years of the mean maxima for the thirty-one days of the month is 42.7° with a corresponding minimum of 17°. In summer a similar influence is exerted by an occasional high temperature, but in considering the absolute maximum records of July and August in column I, it should be noted that in the entire period of forty-one years the thermometer has been 100° or over but eight times in July and only four times in August. The direct sun in summer is very hot, but the mean temperature of the air at 1 P. M. is only 85° in July, 81° in August and 72° in September. The sensible temperature is even less, for the relative humidity of the summer months in Denver is but 49.3

per cent. as compared with 71 per cent. in Boston, 74 per cent. in New York, and 76 per cent. in Chicago. The shade is always comfortable.

In winter while the air is cold, perhaps for a number of days intensely so [see later paragraph concerning Table III.], it is dry and the great flood of penetrating sunshine enables the invalid to remain out of doors comfortably. The low readings of the night which are recorded in columns F and J do not affect the patient, who is then housed. The marked contrast between sun and shade before noted, a difference of over 40°, is of great value in winter, for one has but to step from the cold air of the shade into the sunshine to find the great warmth of its rays, always 40° and often 60° higher. Table II. shows this difference between the solar and air temperatures and the help it offers to the invalids' outdoor life in winter.

TABLE II.—MEAN TEMPERATURES AT 1 P. M.
(Degrees Fahrenheit.)

| 1886. | Solar. | Air. | Difference. |
|---|---|---|---|
| January | 92.5 | 27.3 | 65.2 |
| February | 106.3 | 48.0 | 58.3 |
| March | 107.8 | 41.1 | 66.7 |
| April | 110.6 | 52.3 | 58.3 |
| May | 141.3 | 74.3 | 67.0 |
| June | 142.2 | 75.1 | 57.1 |
| July | 146.5 | 85.2 | 61.3 |
| August | 143.7 | 81.5 | 62.2 |
| September | 132.5 | 72.0 | 60.3 |
| October | 119.5 | 64.2 | 55.3 |
| November | 100.0 | 41.3 | 58.7 |
| December | 100.2 | 45.5 | 54.7 |

There are many days in winter when a thin coat is sufficient in the middle of the day and but a few nights in summer when a blanket is not acceptable. The clothing required in Denver is such as is worn in New York or New England, except that in winter the heaviest overcoat is less constantly needed, and in summer a light coat is necessary after sundown.

*Precipitation.*—Denver has an annual precipitation of a little over fourteen inches, the average total for forty years being 14.1 inches. This is about one-third that of Boston or New York, less than half that of Chicago, and three-tenths that at Jacksonville, Florida. Of the total amount a little over nine inches fall during the months of April, May, June, July, and August, in about even proportions each month, while the autumn and winter months from September to March inclusive divide the remaining five inches also in approximately even distribution.

Columns P and Q of Table I. show the tendency for the rainfall to be below oftener than above the mean. In these tables the mean for May has been seriously raised by the totally exceptional rainfall of 8.57 inches in 1892, as have the corresponding figures in the calculation of sunshine. Barring this unusual year, the greatest precipitation in any May has been 4.8 inches.

The rainfall is in short downpours, a prolonged storm being the exception. Especially in summer it comes in sharp thunder showers in the late afternoon or early evening. It falls too upon a dry, porous soil which rapidly absorbs any moisture, so that within a very short time the ground is dry and hard again—the roads often being dusty within twenty-four hours after a rain.

The snowfall during the winter months is light and lasts but a short time. There is no accumulation on the ground, for the sun and dry wind evaporate it with visible rapidity without its melting into slush or icy pools. As there is no accumulation there is no long melting season in the spring to be avoided, as at Davos.

The precipitation during the spring months, especially in April, is apt to come in a snow storm or heavy rain; but with the mean temperature of 47° and strong sunshine it disappears quickly, often in less than twenty-four hours.

*Wind.*—The mean total annual movement of wind in Denver is 63,684 miles. The distribution of the wind is very regular, showing but few and slight variations from the mean. The average velocity is 7.3 miles per hour, which is quite evenly maintained throughout the entire day as registered by hourly periods. This steady presence of the wind even at this moderate velocity gives the impression of greater movement than is had in a region of irregular calm broken by violent winds. There are occasional high winds in Denver, the maximum velocity attained in thirty-nine years being seventy-five miles for a few minutes only. Such velocities, however, are the exception and Table I, column AA, shows that in a period of forty years, the average maximum velocity of the wind maintained for one-hour periods, between 8 A. M. and 8 P. M. is only 11.9 miles. The highest maximum of a mean hourly velocity is 15.2. The average of these maximum hourly velocities throughout the year is only 13.2 miles.

Together with the velocity must be taken into account the greater lightness of the air at this elevation, a decided factor in the force of the wind.

The dryness of the soil after long periods without rain makes it easily blown by the wind if high. These occasional dust storms are unpleasant but much less frequent than popular accounts would indicate. Moreover, they seem to depend upon some peculiarity of the angle at which the air current strikes the ground, rather than upon the velocity, for every high wind by no means brings a dust storm.

The foregoing discussion with its references to Table I. has dealt with the average climatic conditions as seen over a considerable series of years. Due reference was made to the occurrence of extremes. As it is the weather conditions of single winters which often concern the patient or the physician in selecting a resort for an invalid, a table [No. III.] has been prepared which will repay a careful study. It gives the details of the weather conditions during the five winter months of two years, one of them (1898-1899) selected for its severity, as it was the worst winter for five consecutive years and one of the most trying for an invalid in twenty-five. In comparison, are placed the details for the corresponding months of the year 1899–1900, which was an open, pleasant winter, somewhat above the average. That they are consecutive years adds to the value of the juxtaposition.

The table needs little explanation. The mean temperature in December, 1898, was lowered by one day on which the maximum temperature was 5° and the lowest −20° F. A reference to Table III., columns 4 and 5, will show that the number of days warmer than the mean was double that which was less than the average; in other words, the statistical table was influenced by a single very cold day.

In February, 1899, a similar influence, but to a more marked degree, was exerted by a spell of five very cold days, the rest of the month being very nearly of average temperature. Four of these five days occurred in succession, two had a maximum temperature of 0° F., two of 5° and one of 6° F. The fifth day occurring later in the month had a maximum temperature of only −5°. The untoward influence of these days on the total temperature for the month is emphasized by column 8, where it is seen that excepting these days there were but seven on which the maximum was below freezing. All of these five days, however, were among the fourteen wholly clear days, so that the cold was modified by the diminished humidity and the intense sunshine—factors always to be borne in mind in interpreting Denver weather statistics.

In the data for the following year attention need be called only to the figures in column 8, showing a total

of only eight days from November to April on which the temperature was below freezing all day. A study of these tables in conjunction with the means of twenty-eight years in Table I. will emphasize the general facts already given.

In selecting Denver as a resort for an invalid with pulmonary disease the physician should bear in mind that it is a city of considerable size, but surrounded by a wide extent of open, sparsely populated country. The residence portions of the city stretch out into this open region and the street car system extends to every portion of it. The patient can, therefore, by living in the outlying districts enjoy all the benefits of the climate in pure air and sunshine, and yet be within easy reach of the advantages, material and mental, of a modern, progressive city.

CARROLL E. EDSON.

**Deodorants.**—In the earliest stages of civilization man retained a keenness of scent which was comparable to that possessed by the animals which he hunted. In those days of insufficient sanitary arrangements his dwelling was apt to be associated with a more or less unpleasant odor and he very likely resorted to natural perfumes to hide or disguise them. Perhaps the first use of deodorants came about in this way. Later the frequent combination of filth, offensive odors, and disease was noted and the odor was thought to be the cause of the disease, so that deodorants were then used in the hope that they might prevent sickness. As some of the perfumes used were volatile aromatic oils which we know to have definite antiseptic or disinfectant properties, it was doubtless discovered that these oils not only neutralized bad smells but also prevented decomposition and they were then used for embalming the bodies of the dead. Modern investigation has drawn a sharp line between those agents which are antiseptic or disinfectant and those which are merely deodorants, but the beginning of these researches was founded upon the ancient usages. The sense of smell is still our sanitary monitor, though we know that bad smells do not cause disease and realize that the cause of the smell must be removed, not merely choked for a time. Deodorants and disinfectants are not identical. Some of the deodorants have disinfecting properties, though not all, while many of the most powerful disinfectants have no power to destroy odors. A deodorant therefore is an agent which supplants or destroys foul odors. As a class they may be divided into the true and the false.

The *False Deodorants* all have a distinctive odor of their own, an odor of such intensity that it supplants or conceals the foul odor against which they are employed. When their action is at an end the foul odor may again be perceptible unless indeed both have been removed in the interval. As examples of false deodorants may be mentioned the perfumes both animal and vegetable, crude carbolic acid, iodoform, and the smoke of burning paper, straw, or coffee. They are largely conveniences but may be used to conceal a lack of cleanliness. Their chief danger lies in the fact that they are apt to lull the sense of smell into a false sense of security so that the cause of the disagreeable smell is not attacked and removed.

The *True Deodorants* act either physically or chemically. Those acting physically are absorbents. The principal examples of this group are dry earth and charcoal. Dry earth has an extensive use in the so-called earth-closets where it is used to cover excreta. Dead bodies buried in the ground do not become offensive. Its best form is as a well-dried garden loam. Brick clay is less satisfactory, while sand and gravel are worthless. The loam may be dried out and used over again. It has been calculated that one and a half pounds is a sufficient quantity of loam to neutralize the odors of an average single stool. The same quantity is necessary for 500 c.c. (one pint) of urine. Fluid stools require more loam than solid ones. Fine dry sawdust has been used as a substitute with fair results.

Charcoal absorbs gases and moisture and prevents putrefaction. It loses its power however when it is once saturated. One volume of charcoal will absorb ninety volumes of ammonia, sixty-five volumes of sulphur dioxide, thirty-five volumes of carbon dioxide, about nine volumes of carbon monoxide, and nine and a quarter volumes of oxygen.

*Chemical Deodorants.*—Chlorine is both a deodorant and a disinfectant. Its deodorizing properties depend upon its affinity for hydrogen so that it is able to break down ammonia, hydrogen sulphide, and volatile organic compounds. Solutions of the chlorides are also valuable for this purpose. Such a preparation sold under the name of Burnett's fluid in England and Platt's chlorides in this country has very slight disinfecting powers but a two per cent. solution will act as an efficient deodorant in a sick room. It does not stain, has no odor of its own, and does not injure fabrics.

The oxidizing agents are usually deodorants. Chloride of lime is a valuable one since it is also a disinfectant. It neutralizes the offensive gases as they are formed. The calcium hypochlorite is the essential constituent. Potassium permanganate can be used on foul ulcers in strengths up to 1–1,000. The peroxides, of which hydrogen peroxide is the most important example, are efficient deodorants and it has recently been shown that ozone has marked ability to neutralize offensive odors.

Formaldehyde gas is an excellent deodorant. It combines with the odorous gases to form non-odorous compounds. In its polymerized form as paraform, it makes an excellent dressing for foul ulcers.

Caustic lime is efficient and easily applied. It is used largely in the deodorizing and disinfection of stools, and when applied to the wall of a room or that of a cellar, effectually "sweetens" it.

Many of the metallic salts which have for a base a metal which is capable of forming an insoluble sulphide act as deodorants of hydrogen sulphide and ammonia. In their relative power to fix ammonia, copper sulphate has been ranked at 90 to 100, zinc sulphate at 70 to 80, and ferric sulphate at 20 to 25.

In the great majority of cases the best deodorant is cleanliness, which is both the prophylactic and the curative treatment for foul odors. The prompt recognition and diagnosis of foul odors is more important as a sanitary measure than as a strictly medical procedure, though of course the two may be intimately connected. The growth of many of the pathogenic organisms is attended by the production of no smell so that in these instances the nose is of little help.

RALPH G. STILLMAN.

**Depilatories.**—The consensus of opinion seems to be that the effect of depilatories is exactly that of shaving. By their use the reappearance of the hair is not only not prevented; on the contrary it is actually accelerated. Notwithstanding this undesirable effect, these preparations are in great demand, partly owing to the repugnance that women have for this deformity and partly owing to the alluring but impossible claims made by vendors of such wares.

Depilatories are easily prepared and their immediate action is certain, the visible hairs being quickly destroyed. Numerous formulas have been recommended from time to time but it must be remembered that they are not by any means of equal excellence.

No injurious substances such as those that corrode the skin should be employed in depilatories. This point is of special importance since, when the use of depilatories is once begun, it must be continued and

at intervals that become progressively shorter. One of the most common ingredients is a sulphide or sulphhydrate of one of the alkalies or alkaline earths, though the older depilatories were compounded with caustic alkalies. The powders are mixed to a thin paste with water and are spread on the skin in a thin layer. After a few minutes, when the hair has become soft, the mass is scraped off with a blunt instrument.

Too long contact of the ordinary depilatory is very apt to cause erosions and even obstinate sores. In order to avoid untoward effects, after the removal of the preparation used, the skin ought first to be thoroughly washed and then should be anointed with a bland oil or unguent.

Besides the most ordinary use of depilatories—that of removing superfluous hair from a woman's face—epilation is employed in preparing hides for use. One method for this purpose consists in placing hides in a dilute solution of ammonia and sulphurous acid. Woolly hides are covered on the flesh side with a paste made of potter's clay and the solution just named. The salts of ammonia are sometimes used. In the case of thick skins the sweating process is carried out. Common salt is rubbed on the flesh side. Or the skin is saturated with wood vinegar and exposed at ordinary temperature, or higher, to moisture. This procedure causes a more marked putrefaction so that the hair may be easily removed with scraping knives. Thinner skins are treated in pits with lime or sulphide of sodium. Still more delicate skins are treated with rusma, sulphate of calcium, or gas lime. Rusma is a preparation of one part of orpiment (yellow sulphide of arsenic) and from two to three parts of lime. On account of the arsenic this preparation is poisonous.

Among depilatories used on the human skin the following will serve as examples.

Koller in his work on Cosmetics, says: "According to the patent specification of G. Huettemann and J. Zrzawy, of Brüx (Bohemia), a stable depilatory, which does not affect the skin, is obtained by quenching quicklime with a solution of sugar, and passing sulphureted hydrogen through the resulting solution of calcium saccharate. The process can also be modified by first preparing a solution of sugar saturated with sulphureted hydrogen, and then stirring this up with the lime. This furnishes a pale green mass, which is then mixed with such a quantity of lime that the mixture contains about five per cent. of the fundamental substance. For use, this mixture is stirred up to a pap with water, and applied to the surface to be freed from hair, the whole being washed off again after about ten minutes." Other depilatories mentioned by this authority are calcium sulphide and barium sulphide.

The former is prepared as follows: "Quicklime, calcined to whiteness, is suffused with water—an operation requiring some care, owing to the heat disengaged—the resulting powder being shaken loosely into a high glass, containing a wide glass tube reaching to the bottom and connected with an apparatus charged with water and ferrous sulphide. On treating the latter with sulphuric acid, sulphureted hydrogen is disengaged, and, passing through the aforesaid tube, is immediately absorbed by the lime. When the absorption is complete and the whole of the lime has been converted into calcium sulphide, as may be recognized by the escape of sulphureted hydrogen from the lime vessel, the generator is disconnected, and the calcium sulphide is worked up into a paste, as follows:

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|---|---|
| Calcium sulphide | 2 kilos. |
| Sugar | 1 kilo. |
| Water | 1 kilo. |
| Starch | 1 kilo. |
| Lemon oil | 30 grams. |
| Peppermint oil | 10 grams. |

This paste must be packed immediately into air-tight pots, since the calcium sulphide is decomposed on exposure to air. For use, a little of the mass is moistened with sufficient water to make it easy of application to the skin, and is laid on the hairs to be removed. At the end of a half to three-quarters of an hour, the whole must be washed off with water."

Barium sulphide is prepared by passing sulphureted hydrogen over solid barium hydroxide, the product being mixed with starch paste.

Although its action is similar to that of calcium sulphide, the preparation is not so stable. It is also more expensive.

Barium sulphide paste is made by mixing to a paste barium sulphate, carbon, and linseed oil. After the mixture is thoroughly calcined a dark blue substance, barium sulphide, is obtained. Ten parts of barium sulphide are rubbed fine, and mixed with five parts of zinc oxide and five parts of starch. This depilatory must always be made immediately before it is used. The powder is mixed with enough water to make a soft paste. A moderately thick layer is spread on the skin to be treated. In about ten minutes when the paste is dry, it is washed off with water, leaving a hairless surface.

A depilatory soap is prepared according to the following formula:

"(1) Powdered wheat starch, 20 parts; water, 120 parts. (2) Sodium sulphide, 34 parts; barium sulphide, 30 parts; water, 180 parts. (3) Palm oil, 36 parts; glycerin, 21 parts. Dissolve the powdered starch in 120 parts of tepid water, in one vessel, and set aside for use when wanted (1). In a second vessel dissolve the sodium sulphide (crystals), and stir it and the barium sulphide into the 180 parts of water (2). Add the glycerin. In another separate vessel melt the palm oil. To mix the compounds, make the sulphide solution (2) boiling hot, stir up the starch solution (1), and then gradually stir it into the sulphide solution (2); keep stirring until the starch thickens; add the melted palm oil, mix all well together, and add the perfume (citronella essence, mirbane, oil of lavender, or the like). Before the mass cools and congeals, pour it into porcelain pots or wide-mouthed bottles. Rub the soap into the hair to be removed until the hair loses its crispness and filamentous form, and becomes a pulpy mass; then wash the part well with water, and the hair will all be removed. Should the skin smart after applying the soap, rub in a little olive oil or vaseline."

The so-called Chinese depilatory consists of:

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| Powdered quicklime | 8 parts. |
| Potassium carbonate | 1 part. |
| Potassium sulphide | 1 part. |

The ingredients are finely powdered and are kept in a tightly closed bottle.

Dr. Butte recommends a liquid depilatory having this formula:

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|---|---|
| Alcohol | 12 grams |
| Iodine | 0.75 gram. |
| Collodion | 35 grams. |
| Oil of turpentine | 1.50 grams. |
| Castor oil | 2 grams. |

This is to be applied to the hairy skin once or twice daily for from 3 to 4 successive days, gradually increasing the thickness of the layer.

All depilatories must be used with caution and their application should only in exceptional cases be entrusted to the patients themselves. For a discussion of other methods of epilation see the article *Hypertrichosis*.

EMMA E. WALKER.

**Dermacentor.**—A genus of ticks, family *Ixodidæ*, which contains many species. *D. andersoni* Stiles, the Rocky Mountain Spotted Fever Tick, lives in regions where there is fallen timber or underbrush.

The immature stages feed upon small mammals, particularly rodents, but adults attack only larger domestic animals. *D. occidentalis* is found in the northwestern United States, and *D. venustus* occurs in Texas. See *Arachnida*. A. S. P

**Dermanyssus.**—A genus of ticks, family *Dermanyssidæ*, usually parasitic on birds but sometimes attacking man. These minute pests may cause a severe itching eruption of the skin. See *Arachnida*. A. S. P.

**Dermatalgia.**—By the term Dermatalgia or Dermalgia (Greek, δέρμα, skin, and ἄλγος, pain) is meant painful sensation in the skin, other than itching, occurring independently of any recognized disease or alteration of structure; it is known also as neuralgia cutis, and is a rare affection.

The sensations in dermatalgia are variously described as of a raw, burning, stinging, and often of a darting, boring character; the suffering therefrom may vary from moderate discomfort to positive agony. The affected skin has all the appearance of health, and remains normal during the existence of the disease, unless altered by outward applications or injury; but the surface of the affected part may be so exquisitely sensitive that the slightest touch causes great distress, although firm, moderate pressure may relieve the painful sensations. The extent of area affected varies, but generally only a small patch is painful, and that may change position; sometimes there are several tender places, and occasionally the entire surface is the seat of more or less cutaneous pain.

Etiology.—The disease occurs mainly in middle life, and is more frequent in females than in males, but is by no means confined to hysterical or nervous individuals. The real cause is often extremely difficult to determine; in many cases it is impossible to fix upon any organic or other lesion which could occasion it. Such instances are often spoken of as idiopathic, but it is quite possible that in some of them careful investigation and advanced knowledge may trace an efficient cause in lesions of the brain or spinal cord, as locomotor ataxia, etc.; in certain cases it appears to be reflected from ovarian or uterine disorder. It has been called rheumatism of the skin, and ascribed to the presence of this poison or to that of uric acid; undoubtedly in a certain number of cases it occurs as a pure neuralgia, in connection with anemia, chlorosis, malaria, etc.

Diagnosis.—This is usually easy to establish, no other condition presenting the features described without skin lesions; when, however, applications to relieve the pain have altered the overlying skin, the diagnosis may be obscured. It is to be remembered that the painful sensations are very superficial, in well-defined areas of the skin itself, and not deep-seated, as in ordinary neuralgia, muscular rheumatism, etc.

Treatment.—The general treatment will vary with the case. Anemic and neurotic subjects must be treated on general principles; the rheumatic or gouty state must be counteracted, if past or present history reveals it; special diseases in women must be remedied, and careful study must be given to trace any condition capable of exciting reflex nerve disorder, such as a loaded colon or rectum, etc. Locally, considerable difficulty may be experienced in obtaining much or permanent benefit. Galvanism affords some relief, and it has been recommended to apply blisters, with morphine, to the part. The surface feels most comfortable when firmly bound with a dressing which prevents all friction and an ointment of tar and zinc, with belladonna or aconite, spread thickly on lint, will often serve to keep the part free from pain while applied. L. Duncan Bulkley.

**Dermatitis.**—Dermatitis in its general meaning signifies an inflammation of the skin. A dermatitis or simple reactive inflammation of the skin is possibly the most readily studied of any inflammation of the body.

An inflammation of the skin may be considered as the successive changes occurring in the injured living tissue. Anything either from without or from within the organism that may create damage or irritation to the skin can be a determining cause. These inflammatory changes may either be followed by reparative ones or the processes go on to entire destruction of the tissue.

The term dermatitis is a generic one, therefore rarely employed. It is usually associated with the known or suspected cause.

The avenue of infection must be by one of two pathways, either directly from without through the surface of the skin or from within through the action of the various organs by means of the blood-vessels.

Pathology.—If the infection is by the first pathway, and the active cause is other than bacteria, it must stimulate the epidermal cells so that they produce a chemotactic material. If the active cause is bacterial, it must produce a toxin which has chemotactic ability. By virtue of this chemotaxis, the subepidermal capillaries pass through a momentary stimulation, then become dilated and an extravasation of serum follows. The attracted leucocytes, because of their ameboid movements, pass onward to the point of local irritation and make an attempt to destroy the irritant. The destruction of leucocytes sets free a ferment which, acting upon extravasated blood plasma, produces fibrin and a serous exudate. The serous exudate may assist in the destruction of the enemy and also help mechanically, by forming an artificial wall, to prevent further extension. The leucocytes, the eosinophiles of the blood, and the plasma, all play an important part in the reparative effort. Polynuclear leucocytes incorporate the bacteria and destroy them. The eosinophiles destroy by means of secretory products in the form of granules.

When the invasion is via the internal route—that is along the internal blood-channels—the capillaries of the corium are the first to suffer the dilatation and phenomena just described for the subepidermal vessels. The infiltrating elements push upward toward the surface where the invasion is intense subcutaneously. As in the former variety the reparative reaction will depend upon the nature and extent of the inflammatory involvement.

The use of the microscope greatly aids in differentiating the varied ocular manifestations of a dermatitis and individualizes them according to their cause.

Varieties.—In studying dermatitis it is customary to do so from the standpoint of four general divisions, namely, erythematous, papular, vesicular, and pustular.

*Erythema* is characterized by redness and heat and may be only a simple engorgement of the blood-vessels, some dilatation, with a slight amount of exudation. It is just beyond the state of hyperemia. In appearance it may be localized, or more or less diffuse, and persistently varies—in the fugax type disappearing and reappearing at intervals from a few minutes to several hours, or it may remain for a number of days to several weeks. In some cases the serous exudation will be sufficient to produce a local swelling. This may be so great, as in the facial region, as to render the parts unrecognizable. In areas where the skin is lax, as in the eyelids, genital regions, etc., the patches will puff out suddenly. The lesions may

or may not be symmetrical or may appear to spread by continuity from a primitive spot. Occasionally the entire body is involved.

*Vesicular dermatitis* is produced by the exudation of serum into the epidermis in small areas. The tenseness of the walls of the vesicle depends upon its location in the epidermis. If the serum is transfused slowly into the cuticle it forms a vesicle more or less large but which ruptures very easily upon pressure. If the exudation is violent there may be an upheaval of the entire epidermis forming a tense not easily rupturing vesicle or a loose easily rupturing one, allowing an open sore or ulcer to remain.

Vesicles may arise singly or grouped on a more or less erythematous base which may or may not be elevated. They may arise independently, scattered over the body with a scarcely visible areola; or there can be a single vesicle on an erythematous base which, upon rupturing, seems to spread the disease. Vesicles by coalescence can form bullæ, which rupture and leave a raw, oozing, but seldom bleeding surface, which continues oozing until reparative work forms the new epidermis.

*Pustulation* or pustular dermatitis may occur primarily but more often the condition is secondary to one of the other forms. It is due to an invasion by pus-producing organisms, perhaps most often by the staphylococcus. Crusting is a usual accompaniment in nearly all of these cases, and wherever it is observed, there has been of necessity an oozing of serum. This mixed with pus and more or less extraneous débris accounts for the crusting.

It must be borne in mind that the lines of demarcation between these different divisions cannot be too sharply dran; that there may be and in fact usually is a blending of two or more of the varieties in any given case with the diagnosis resting upon the dominating elements; because of these in certain instances the term "mixed infection" is applied, the necessity for which is readily apparent when it is remembered the blurring of the picture from excoriations, produced chiefly by scratching.

Symptoms.—Subjective symptoms of these conditions are usually a sense of heat or burning and itching, which may be severe, and in some cases there may be pain. There may be, too, certain prodromes, as shown by the general malaise, perhaps nausea or vomiting, headache, vertigo, and at times considerable nervous excitation; and a common forerunner of an outbreak is a cutaneous irritation known as formication.

The period of latency between the time of exposure to the irritant or ingestion of the medicament varies from a few hours to several days or longer. The duration of an attack depends upon the nature and virulence of the cause; also upon the reparative ability of the organism. A simple dermatitis will require but a few days in which to heal while a more violent one may require many weeks and will be complicated too by remissions.

Treatment.—Simple dermatitis, mild in character, will require little or no treatment, nature being easily able to repair the damage. Suppurative forms may be readily controlled under proper treatment. On the other hand a dermatitis that is only a cutaneous expression of some systemic derangement or is the result of certain nervous explosions may be healed, but recurrences are apt to be frequent if not unavoidable.

Rose Hirschler.

**Dermatitis Atrophicans Idiopathica.**—See *Atrophia Cutis Idiopathica.*

**Dermatitis, Blastomycetic.**—See *Blastomycosis.*

**Dermatitis Bullosa Plantaris.**—This is the affection described by Cautlie as "foot-tetter." It is a tropical skin-disease, commencing with blebs on the sole of the foot which break and are followed by extensive scaling with intense itching. The condition improves or disappears in cold weather, but patients returned from the tropics often suffer recurrences in the summer time for years afterward. The cause is unknown. Some temporary relief may be secured by frequent and regular bathing with green soap, followed by the application of a dusting powder consisting of equal parts of bismuth subnitrate and boric acid. Manson has recommended a daily foot bath in two per cent. carbolic acid for half an hour.

J. F. Leys.

**Dermatitis Calorica.**—This is a dermatitis which may be produced by heat (dermatitis ambustionis) or by cold (dermatitis congelationis). Both heat and cold may produce as lesions, erythema, vesicles, pustules, ulcerations, and sloughs.

In the resolution of the lesions there may be a simple scaling, a crusting with exfoliation, or, if the destruction has been deep, there may be an extrusion of a slough before granulation and healing take place. The slough may be moist, or a dry gangrenous mass, or, as sometimes seen, of a peculiar, alabaster white. In this instance it may take one to two weeks before a slough is thrown off and reparation has begun. Dermatitis ambustionis may be produced from the rays of the sun (sunburn), is often painful and difficult to relieve, as seamen and mountain climbers can well testify. Ice and snow on the mountain seem to accentuate the strength of the sun's rays.

Dermatitis Ambustionis.—There is a generally accepted division of the burns produced by heat into three divisions.

The *first degree* (dermatitis ambustionis erythematosa) recognizes the simple burns, which cause little destruction and heal rapidly without or with treatment. Pain is the main symptom.

The *second-degree* (dermatitis ambustionis bullosa) burns are of a deeper character. To the symptoms of the first degree are added vesicular and bullar formation. The tissues become more deeply involved. There is pus and eschar formation followed by more or less severe scarring. There is less tenderness and actual pain. There may be a toxic absorption producing general symptoms of shock.

The *third degree* (dermatitis ambustionis escharotica) means a serious involvement of extensive areas of tissue, followed by possible or probable death. A large searing—preventing the proper activity of the physiological action of the skin, the formation of sloughs—a possible absorption of toxins or ptomaines from the broken-down tissue, a gross destruction of leucocytes, are possible causes of death of the individual although the actual cause of death is obscure.

It may take a day or two before the hopelessness of a case manifests itself. It is said that one-third surface involvement is a serious menace to life and one-half involvement is probably death. For the extremes of age the prognosis too, is less good.

Organic complications have been found to occur, as duodenal and gastric ulcers. Complications of pyemia, erysipelas, and tetanus abet a fatal termination.

It is believed that it is the ultraviolet or chemical rays that are the source of irritation in the sunlight.

Dermatitis Congelationis.—The dermatoses produced by cold are found in varying grades from an erythema to a deep tissue necrosis. There is the same somewhat arbitrary division here as in dermatitis ambustionis.

The *erythema pernio* (chilblains) or first degree, usually occurs on distal parts of the extremities, where the circulation is weakest as on the hands and

feet, nose, and ears. Those of depressed circulation or of malnutrition are ordinarily susceptible in mildly cold climates. In severe cold the average healthy individual may succumb.

The parts are of a dusky hue, reddish or bluish, appear shiny, and are cold to the touch. The erythema may cover a small surface; there may be an extensive involvement, including one or all fingers and toes or even the feet and hands entirely; and it may be accompanied by puffing and swelling. When the parts are brought to an artificial heat they sting and burn or itch often intensely.

The *second degree* considers a more severe congestion. With the symptoms of the first, there is added more or less vesiculation with serum exudation.

In the *third degree*, there is added a probable coagulation necrosis (ulceration), and gangrene. In the extreme cold, parts have become so stiff and brittle as to break on touch.

As in all persistent ulcerations, and these may be very persistent, any pus-producing bacteria find a ready source for proliferation; and other skin diseases may become grafted upon them. They are frequently very resistant to treatment, and unless cured return as soon as cold weather begins.

Treatment.—In the treatment of burns, the local application depends upon the severity of the burn. It may be sufficient in mild cases to use a dusting powder of bicarbonate of soda or iced compresses of it or of boric acid; or olive oil immediately applied is good. Leadwater, laudanum, and carron oil are comforting lotions. A picric acid solution painted upon small areas has been extolled as a remedy. In the grave cases, internal treatment for shock must be instituted and sometimes a continuous immersion in a carbolized bath is beneficial. Skin grafting may be found necessary.

Chillblains and frost bites at first should be gradually brought back to normal temperature by immersion in snow or iced water, followed by soothing applications such as zinc oxide, ichthyol, boric acid, or salicylic acid ointment. Pyroligneous acid is sometimes very effective on old cases of pernio.

Vesicles and bullæ should be incised. Shock should be treated by supportive medication the same as with burns. Sloughs should be cared for by surgical measures. Rose Hirschler.

**Dermatitis Coccidioides.**—This affection, otherwise termed coccidial blastomycosis and protozoic dermatitis, is held by some authorities to be a variety of ordinary blastomycosis (*q.v.*) and by others to be a distinct affection or separate member of a common or group disease. Clinically and anatomically there are no differences. The incidence differs from that of blastomycosis, as most of the few recorded cases have appeared in two foci, viz., Buenos Ayres and a limited area in California. A marked characteristic of all cases thus far recorded is the fatal termination. The actual mark of differentiation from ordinary blastomycosis lies in the method of reproduction of the fungus. In the latter this is effected solely by budding, while in the affection under consideration it is by endosporulation. Since under artificial cultivation ordinary blastomyces exhibit the latter behavior a distinction between the two maladies is difficult to uphold. E. P.

**Dermatitis Exfoliativa Epidemica.**—*Synonyms.* Savill's disease; epidemic eczema; dermatitis epidemica.

In the summer of 1891, chiefly during July and August, a series of cases appeared in London hospitals, infirmaries, and asylums numbering possibly 500. Because of the simultaneous appearance, or rapid succession, the epidemicity of the disease strongly appealed to those in charge. Dr. Savill studied the cases perhaps most thoroughly and wrote a monograph concerning them, hence the synonym "Savill's disease." Crocker also saw a number of cases and has written an interesting description in his own textbook. According to him, the disease appeared in two types, a moist one simulating eczema and a dry form indistinguishable from pityriasis rubra. In America only a few cases have been recorded, chiefly by Fordyce, Colby, and Winfield.

The disease may or may not be preceded by prodromes, such as anorexia, nausea, sore-throat. In nearly all, the outbreak was attended by itching, in some cases severe.

Fig. 1652.—Dermatitis Exfoliativa. (Case of Dr. Schamberg.)

The parts first attacked are the upper extremities face or scalp; it is said nearly sixty per cent. begin here while less than twenty per cent. begin on the lower extremities.

The lesions start as indurated, bright red, acuminate papules, irregularly grouped near the hair follicles; as these develop and coalesce they frequently form thickened patches. In some the papules are surmounted by vesicles, which rupturing leave an oozing surface, in appearance similar to an eczema, and drying are followed by an indurated patch. In some instances, instead of beginning as papules, the lesions begin as erythematous spots, which become infiltrated and sometimes edematous. Occasionally a few cases begin as marginate and circinate patches resembling erythema nodosum; in others, papules coalesce to form annular lesions with central vesiculation.

These lesions last from three to eight days constituting a sort of first stage. Confluence then ensues covering large areas, sometimes the entire body. The skin becomes a brilliant red, thickened, mainly dry, and scaling with a more or less thick scale; if there is an exudation crusting will follow. The scaling usually is enormous, measuring pints in twenty-four hours. In some the scale is a soft fine powder. Itching is severe.

A sort of second stage lasts anywhere from three to eight weeks, to be followed in the cases that recover by the stage of involution. The skin is often pigmented for a considerable time, accompanied by induration, covered by a smooth, shining, and stiff epidermis which readily fissures.

In severe cases, the nails and hair are shed, even though the scalp is apparently not affected. Complications follow, namely, conjunctivitis, at times ectropion; involvement of the heart, kidneys, and lungs may take place; occasionally gangrene occurs.

Fatalities have averaged from five to thirteen per cent.

The cause of the disease remains as yet undiscovered. Cocci were isolated and studied by Savill and Russell but their connection with the disease could not be demonstrated. Echeverria believes that he found some unique change in the nuclei of the prickle cells.

Treatment has little affect in aborting the disease but parasiticides are beneficial.

ROSE HIRSCHLER.

**Dermatitis Exfoliativa Neonatorum.**—(Ritter's disease; Dermatitis Exfoliativa Infantum.) This is a rare disease, first described by Ritter in 1878, and so named from its close similarity to dermatitis exfoliativa of adults. It is found most often in institutions for the poor.

It may be defined as a dermatitis of rapid development, occurring early after birth, distinguished by excessive exfoliation of the epidermal cells, leaving a reddened, excoriated, or dry surface, but which may be also serous. In some cases there have been noted vesicles and bullæ in patches, with serous undermining, and therefore some writers have believed the disease to be a pemphigus or one closely allied to it.

The disease is prone to begin from a single focus, the chin being quoted as a frequent site of its origin, from which other surfaces become involved. The mucous membrane of the mouth, nose, conjunctiva and the mucocutaneous margins may be involved, and be accompanied by excoriations and crusting, the entire surface may become a dry, scaling mass with staphylococcic infection superimposed to be followed by deep-seated abscesses and even gangrene.

The disease usually begins during the first or second week after birth, rarely as late as the fifth week. The duration depends upon the virulence of the infection and the susceptibility of the patient. More often the course is rapid. Some claim, however, that if the patient can withstand the attack for two or three weeks prognosis is favorable. Subjectively, there are constitutional symptoms of severe inanition. Many die of marasmus, others through pneumonia or some morbid intestinal phenomena.

The etiology and the pathology are obscure. There is no doubt the disease is confused with acute pemphigus neonatorum. Ritter believes in the septic origin of the disease, while Kaposi considers it an exaggerated form of physiological exfoliation of the skin of the new-born. The histopathology shows merely what one would expect to find in such cases of dermatitis, viz., a superficial inflammation with oozing, and crusting from extraneous débris and an abortive attempt at new keratin formation, hence the exfoliation. It is said that only fifty per cent. of the affected recover.

The treatment par excellence is to maintain the infant's vitality by careful regulation of the diet, preferably mother's milk, and every attempt made to keep the mouth in condition to take food. To this end the greatest care should be exercised to soften and remove crusts especially those formed at the angle of the mouth. The body warmth should be carefully maintained, and comfort obtained by keeping the infant wrapped in cotton and oily dressings. The application of oil aids in the nutrition of the body as well as cleansing of the skin, but if this is not applicable or helpful, a soft ointment may be substituted.

ROSE HIRSCHLER.

**Dermatitis Gangrænosa Infantum.**—See *Varicella Gangrænosum.*

**Dermatitis Herpetiformis.**—*Synonyms:* Hydroa bulleux (Bazin); Hydroa herpetiforme (Tilbury Fox); Herpes circinatus bullosus (Wilson); Dermatite polymorphe.

Dermatitis herpetiformis is an inflammatory, superficially seated, multiform, herpetiform eruption, characterized mainly by erythematous, vesicular, pustular, and bullous lesions, occurring usually in varied combinations, accompanied by burning and itching, pursuing usually a chronic course, with a tendency to relapse and recur.

Dr. Louis A. Duhring was the first careful observer of this disease which had previously been confused with pemphigus and other diseases where multiformity of lesions were present, as in eczema. However, while pemphigus jeopardizes life, dermatitis herpetiformis, though very chronic in its course, is not fatal.

The disease may appear in either sex and at any age although there is a possible slight predilection for the ages between thirty and sixty years. The disease is usually manifested in those patients of a depraved state of health, and when any organic disease is present such as a disease of the kidney or heart, or when the nervous system is very much at fault. Pregnancy (herpes gestationis), the puerperal state, and menstrual disorders are predisposing causes. The supposition is that a toxin is liberated, particularly in the puerperal and pregnant conditions, which acts as a poison upon the nervous system which in turn is productive of the disease.

According to pathologists there is first a vasomotor disturbance in the capillaries of the papillary layer of the corium. Following the congestion of the blood-vessels there is a diapedesis of the leucocytes, eosinophiles, and polynuclear leucocytes with serum. As the exudation increases, the epidermis, which has been but passively involved, is elevated and a vesicle or pustule is formed.

Upon the examination of matured bullæ thirty to ninety-five per cent. of the blood cells present in the serum are seen to be eosinophiles. These are considered by pathologists to be of diagnostic importance.

The disease is usually preceded by more or less ill-defined prodromes, that is, malaise, slight elevation of temperature, and chilliness.

VARIETIES.—The various types may be classified as erythematous, papular, vesicular, bullous, pustular and multiform.

The *erythematous* type may be distinguished by red patches, or a diffuse erythema with or without an urticarial element manifesting itself as an edema. The color may be distinguished, as Duhring expresses it, as a raspberry red, or mottled, tinged with a yellowish, brownish, and variegated, and later with more or less pigmentation. Papular and vesicular lesions may occur with them.

The *papular* variety may be exclusively papular but if markedly so it is rare. It is seldom well developed. The maculopapular lesions are frequently seen in the multiform types.

In the *vesicular* variety the vesicles may develop without an erythema, and alone but they usually come in groups of two to six or more in number, some of which may coalesce and together have an erythematous areola. The vesicles may be flat, or semiglobular, and when they coalesce they give a "puckered" and angular appearance to the lesions characteristic of the disease. Vesicles are usually tense with firm walls and many fill again after rupturing.

The *bullous* lesions are variable in size. They may be semiglobular, tense or flaccid. They act as the vesicular type, running together and forming multilocular lesions. Whenever they do this, they form the peculiar puckering. These too have an erythematous areola. Small pustules may appear in the neighborhood and erythematous and vesicular lesions may be present.

In the *pustular* variety there are usually two kinds of pustules found; a small one, miliary and flat, the other large, elevated, acuminate or rounded, situated upon an inflammatory base. As in the vesicular type there is a tendency toward a grouping of three or four pustules. There may be a combination of vesicles and blebs to confuse the picture, although it is unusual. They are pustular apparently from the incipiency of the lesion.

In any of the vesicular varieties, vesicles, bullæ, or pustules may arise with or without an areola. They may be accompanied by small lesions of their own type or pustular, arranged about them in rather a crescentic grouping and they may become hemorrhagic or necrotic in the center as is often seen in the central necrosis of a herpes zoster vesicle. The tendency of the pustular type *per se* is not to mix with the other types. Any of these varieties may recur as a distinct entity again and again and at the last to recur in the multiform variety. This is distinctly recognized in the multiplicity of the lesions. Upon observing the disease one would immediately conclude it to be an herpetiform eruption. It consists of erythematous patches, a combination of vesicles and bullæ upon erythematous bases having the puckered, necrotic look of a herpes. There may be papules present and there may be pustules with broken vesicles and some excoriations which are not as marked as one would expect. The lesions are generalized with no special predilection for location.

The burning and itching are very intense; rupturing the vesicles seems to cause relief.

The disease may persist for weeks and then disappear, only to recur again and again for years.

Treatment.—The treatment consists in trying to remove the cause, thus if it is due to nervous depression, kidney disorder, uterine conditions, etc., arsenic has often been of great value. When given it must be used in ascending doses until an impression is made. It may be given either by the mouth or by hypodermic injection. Many cases are too sensitive for the employment of arsenic. Other drugs may be tried, as nerve tonics, phenacetin, cannabis indica, iron, quinine, strychnine, etc. Bullæ should be incised. Lotions containing resorcin, ichthyol, boric and phenic acid, and tar may be used. Duhring advises the use, particularly in the chronic forms, of a sulphur ointment well rubbed in. Dusting powders may be of advantage with mild ointments as zinc oxide and cold cream. Rose Hirschler.

**Dermatitis Medicamentosa.**—*Synonym:* Drug eruptions.

Dermatitis mendicamentosa includes those skin eruptions which appear after the introduction of a drug by the mouth, by the rectum, or by subcutaneous injections. The rashes produced by absorption through a wound or by surface friction belong to the class produced by external irritants and are considered in the article *Dermatitis Venenata.*

The cause may be too large an initial dose immediately precipitating a rash. A drug may be continued over a period of time in moderate doses, when suddenly an intolerance arises and the drug must be discontinued. After eliminative procedures have been instituted, the patient may be able to take the drug again, or may never afterward be able to take it without a cutaneous reaction. There may be originally an inability on the part of the individual to take the drug so that a very minute dose would be toxic. Or there may be a slow accumulation resulting in toxic symptoms, the skin partaking in the general manifestation.

My notes recall a patient, a white man, with lupus erythematosus. Moderate doses of sulphate of quinine were given him for this condition. After some time an erythema, swelling, with some exudation, and plentiful desquamation, accompanied by severe burning and pain with prostration, arose and continued for some time after the removal of the drug. Time elapsed when again the drug was given in the same dosage. The desquamative dermatitis was repeated. It was later found that a small dose, no matter in what combination it was included, would be productive of the same result. We have noted the same thing in a negro woman with lupus erythematosus.

There may be a family susceptibility to a drug, and then there are those who cannot stand any one of a special class. For instance, a patient came to us at the skin clinic of the Polyclinic Hospital. He said that we should give him no cathartic except licorice root, because he always "swelled up and peeled afterward" and was quite ill, and it took two or three weeks to recover from the attack. Inadvertently we proved it. Having in time forgotten his remark we administered a cathartic. A profound desquamation took place, preceded by a rise of temperature and a generalized swelling with some exudation.

One of the reasons for the inflammatory reactions occurring in the skin is a probable inability on the part of one or more of the internal eliminating organs to take care of the poison. The nervous system may be the responsible agent, possibly due to a centric or a peripheral poisoning. The vasomotor nerves must play an important part in the exhibition of the lesions, for by far the most common rashes are erythematous, urticarial, and swelling with redness.

The satisfaction that comes to the practitioner when he discovers the cause of the eruption is often very great. One realizes this when one sees how simulative the rashes are at times to communicable diseases, as scarlet fever, measles, and syphilis; and how careful a search must be made into the history of the case to eliminate such a possibility.

It is occasionally seen that the rash appears some time after the drug has been discontinued. It is known that nursing babies develop a rash like the mother's and they have been known to have become affected when the mother was not susceptible.

The erythematous rash and swelling, after removal of the drug, disappear more quickly than is usual when something else is the cause. Those lesions that appear like condyloma and papilliform growths and the deep ulcerations, as in the bromine and iodine rashes, have the longest duration. Desquamation is often very persistent.

The type of lesions may be presented as erythematous, urticarial, papular, vesicular, pustular, carbuncular, ulcerative, purpuric, gangrenous, or combinations of them all. They may be localized, usually symmetrical, or they may be diffuse.

The following is a list of the more common drug eruptions; there are many more not included, the limited space not warranting it: Belladonna, quinine, turpentine, sulphonal, antipyrine, chloral, copaiba and cubebs, opium, aspirin, arsenic, iodine, bromine.

Belladonna.—The drug produces an erythematous rash as is so often seen in the blush following a hypodermic of atropine. The erythema usually is seen on the face and upper part of the body, but it may be generalized. It is said to occur more frequently in children, probably because it is so commonly used as a febrifuge. It closely simulates scarlet fever, but usually fades away, on omission of the drug, without desquamation.

Quinine and its derivatives produce a scarlatiniform erythema, brilliant in coloring, and very like an exanthem. It is usually a generalized rash. It may be vesicular, pustular, in wheals, purpuric, or in local gangrenous areas. It is very frequently followed by desquamation of more or less severity.

Turpentine produces an intense erythematous rash, which may be accompanied by papules.

Sulphonal produces an erythematous rash followed by desquamation. This may be like a generalized scarlatinoid rash. A case has been recorded where the efflorescence was seen on the thighs alone; another, upon the trunk; macules, vesicles, and purpuric spots have been noted, but are rare.

Antipyrine most commonly induces an erythematous rash, often followed by pigmentation. It may be urticarial, erythematopapular, vesicular, purpuric, bullous, pustular, or of mixed type. The eruption may be generalized or symmetrical. The chest, abdomen, back, and thighs are the most common locations, and the flexor surfaces more than the extensors. Vesicles may be scattered on the face, particularly around the mouth, on the genitalia, and on the mucous surfaces. There may be erythematous patches or macules which become confluent and form large areas of solid color or "marbled" effects. Miliaria-like papules occur frequently, probably because of the excessive sweating which is common. Itching is the most regular symptom and often severe. Mibilli demonstrated the drug in the serum of the bullæ by the use of perchloride of iron obtaining a red reaction (Crocker). There has been noted, as I have seen personally with belladonna, a recurrence of the rash in the original location upon a repetition of the drug. There is usually no difficulty in the involution of the rash when once begun. There may be constitutional symptoms due to the medicine.

Chloral causes an erythematous or scarlatinoid rash, followed by desquamation, with febrile reaction; may have urticaria, vesicles, bullæ, pustules and ulcerations. The mucosæ may share in the rash, and in the debilitated and the young, corneal ulcers as well as those of the mucosæ are not uncommon.

Copaiba and cubebs are usually taken together for a venereal disease. For this reason, a macular rash, very much like the roseola of syphilis is often misleading. A rash is commonly due to copaiba. The lesions are usually erythematous. A macular rash, or a maculopapular one, over the abdomen and extremities, particularly around the joints, is characteristic. It may be generalized and look very morbilliform. Other types of lesions are rare. It is associated with itching and discomfort, and may come out rapidly after the taking of but a few doses, or may require a number. It fades rapidly after stopping the drug.

Aspirin has been known to produce a generalized scarlatinoid rash and a severe urticaria of some duration even after the drug was discontinued.

Opium may produce an erythematous, scarlatinoid rash, sometimes accompanied with a great deal of swelling and itching, and often terminates by desquamation; it may be morbilliform with macules or maculopapules, and some of the papules may be surmounted by tiny vesicles (Crocker). Vesicles, pustules, or carbuncular lesions are uncommon. The writer has noted on a paregoric habitué, dry scaly irregularly shaped patches upon the palms of the hands.

Arsenic is a drug which has for many years been extolled as a remedy for skin diseases. For this reason it has been repeatedly used when a rash was first manifesting itself. It has been noted that at such times the affection became more violent, lessening in virulence as the drug was discontinued. Arsenic is a common remedy in nervous affections as chorea and epilepsy; and a patient may have the drug given by various doctors over a period of years.

Fig. 1653.—Dermatitis Medicamentosa, Due to the Ingestion of Copaiba. (Case of Dr. Schamberg.)

Often under such circumstances the drug is cumulative in its action, and may produce a pigmentation which becomes darker in time, of a chocolate or Vandyke brown hue. In the diffuse form it may be mottled with lighter and darker areas. The hair follicles are at first not involved, flecking the skin with white which disappears later. When severe, the skin may become so dark as to be almost black. Any lesion may be followed by pigmentation. This color scheme may entirely disappear under the proper elimination with discontinuance of the drug, or it may remain for several years or become permanent. It is most often found upon the trunk but it may be upon the face, neck, and extremities. The pigmentation is said to be preceded by an erythema; it is doubtful if this is always true. The drug may produce, too, after long-continued usage, keratotic areas of various sizes upon the palms and soles of the

feet, on the leg (anterior surface particularly), and may be upon the face and arms. The small keratoses may disappear but the larger ones are apt to remain. Underneath these horny excrescences are sometimes found epitheliomatous disease. These may be multiple.

Arsenic may cause any of the cutaneous lesions, erythema, urticaria, vesicles, papules, pustules, ulcerations, purpuric and polymorphous lesions; possibly of the acute type the urticarial is the most prevalent. The palms and soles may become unusually pink.

Herpes zoster is not an uncommon product of the drug. Neuritis is a frequent symptom. Other subjective symptoms are burning, pricking, itching, numbness, and anesthesia. There may be a chronic diarrhea with or without nausea.

Iodine and its compounds are a common cause of eruptions. The most usual type is possibly the papular or the papulopustular, the so-called "iodide acne" or "pimple." There may be produced an erythema, a vesicular or an urticarial rash. Occasionally the forms may be polymorphic, simulating a multiform erythema. There may be bullous lesions which are uncommon, and bizarre types of mixed lesions. Papillomaform and condylomaform lesions are not uncommon. When there are deep ulcerations, they are difficult to heal. Scarring is rather apt to be seen after a sévere acne, or condylomaform ulcerative lesion. Purpura may be present, fortunately not commonly so.

The bullous and the purpuric lesions are usually evidences of a serious condition of the patient. Very frequently there is an underlying kidney and heart dyscrasia.

The acneiform lesions are usually found upon the face, upper chest, shoulders, and upper arms but may be scattered over the body. The erythema, not common, may be seen in patches upon the trunk, extremities, or face; or may be diffuse, rarely scarlatinoid. Occasionally an erythematous patch may be studded with minute vesicles.

Bullous eruptions may be found with the bullæ sometimes singly, scattered, few in number or abundant, or they may become confluent. They are usually found located upon the arms, hands, face, and sometimes other parts of the body. Occasionally the bullæ break, leaving raw, oozing ulcers beneath. The affected part may be swollen and present an erysipelatous appearance. The condition is grave. Patients have been known to succumb from it.

Two or more papules may coalesce and form irregularly shaped tubercular lesions which may remain for a long time. These are seen especially upon the face, upper trunk, and arms. The condylomaform lesions sometimes present small miliary abscesses which may continue with ulcerations for a long time.

The rash may develop any time, from a few days in the very susceptible, to a week or two in those less susceptible; it may continue to appear for some time after the drug has been discontinued. Involution of the lesions may take from several weeks to a month or longer.

A nursing baby may acquire the rash from a mother taking the drug. This is also true of the bromides; in fact the eruptions from the iodides or bromides are very similar and often cannot be told apart.

Bromine compounds frequently produce rashes. The papulopustular types (bromide acne) are possibly the most common. They frequently look as though they contained considerable pus but upon puncture with pressure there may be very little. These are located upon the face, chest, between the shoulders, and sometimes upon the upper arms, or they may be scattered over the body. They are usually more or less painful and more persistent than acne vulgaris. There may be a confluence of two or more papules or papulopustules. These may have several pinpoint pustular openings or may form one large opening. They usually scar but may leave only a stain on involution.

The bromides may produce lesions like the iodides, erythema, vesicles, wheals, furuncles, carbuncles, and ulcerations. Some of the ulcerations may have a rupial crusting. Also like the iodides, the bromides produce peculiar fungoid-appearing formations. These are more particularly found upon the legs, arms, sometimes face, but may be present upon the body. Cases have been known to simulate closely mycosis fungoides. Some of the papulotubercular lesions may develop in time to pustular ulcerations, the type of bacteria depending upon the organism that may have come into contact with the lesion or was resident on the skin before the lesion developed.

Fig. 1654.—Dermatitis Medicamentosa, Due to the Ingestion of Bromides. (Case of Dr. Schamberg.)

A case placed under my care had very large ulcerations which had developed from papulopustules. These ulcerations were filled with tiny openings simulating very closely minute miliary abscesses of blastomycosis. The abscesses communicated by canaliculi and altogether exuded considerable pus. In this case the contamination proved to be pyocyaneus bacteria which possibly created the bad odor. The lesions beginning as papular, after they became about the size of a split pea, seemed to be surmounted by a broad, flat vesicle filled with yellowish pus, but upon puncturing there was no pus in the cavity and the covering could be lifted easily. The base was fungoid which raised upward in a heap and contained inside itself a few of these miliary pin-point abscesses. If the covering was not ruptured purposely it would eventually open and peel away. The periphery was exceedingly painful and an erythema extended some little distance around it. If another lesion happened to be near they would coalesce. The large lesions chiefly consisted of a coalescence of the smaller ones. The entire extremities both lower and upper, including the face were very much involved—with none on the trunk, excepting one seen on the mons veneris.

This case resulted from taking four drams of sodium bromide in an ounce of solution in divided doses, taken in a brief period of time. When the writer saw the patient about a month afterward, the

rash had appeared and new lesions were still manifesting themselves. It required about two months to disappear entirely, leaving slight scarring.

The bullous rashes are less common than the bullous rashes of the iodides. Erythema and vesiculation are not very common either.

Bromide rashes, like those of the iodides, may be given to a suckling babe through the mother, though she herself may have no rash. The appearance of the eruption varies in time from a few weeks to a month or two.

Heart and kidney disease may be the cause of a purpura very similar to that caused by these drugs.

The susceptibility of patients varies in regard to dosage, but even small doses may act as a poison to the skin.

Serum Rashes.—The injection of animal serum is often followed, after a period of delay, by an eruption. This quiescent period may last from one to twenty days or a month. The rash may first appear at the site of the injection, disappear, to recur again in a general rash. Many individuals are not susceptible to the serum. The most commonly known rash is that following the use of antitoxin for diphtheria because of its extensive use.

Schamberg says that "it has been proved that the toxic manifestations are not due to the contained antitoxin, but in all probability to certain albuminous bodies in the serum." The scarlatinoid rashes may appear as early as the second or third day.

The lesions may be typified as urticarial, with frequent edema (most common), erythematous, vesicular and purpuric (rare), and polymorphous. There may be a recurrence of the rash, the interval being from a few days to several weeks. It is commonly generalized but may be frequently seen upon the extremities, buttocks, and less usually upon the face. There may be a few lesions only, or a profusion. The duration is but a few days—two, three, or maybe five. The scarlatiniform and macular erythemas may be mistaken for scarlet fever and measles.

The subjective symptoms are usually severe itching, and pain at site of injection; the temperature is variable, commonly 101°–102° F., or it may rise to 104°. Following, there may be more or less prostration, and often swollen joints with pain.

Rose Hirschler.

**Dermatitis Nodosa Rubra.**—This disease has been described by Castellani in Ceylon. It is characterized by the appearance, on the face and over nearly every other part of the body, of an eruption of large, bright red, angry looking, hard papules and nodules, varying in size from a small pea to a large one. Their surface is smooth, never umbilicated or scaly. They do not form pustules, but after a long course of from six months to a year or two they undergo resorption leaving no scars or zones of hyperpigmentation. There is no fever. The important symptom is the intense unbearable itching, for which the patient seeks relief. For this Castellani recommends a lotion of salicylic acid two per cent. in dilute alcohol, and some bland ointment. The disease is uninfluenced by mercury, iodides, or arsenic.

J. F. Leys.

**Dermatitis Papillaris Capillitii.**—*Synonyms:* Acne keloid; Folliculitis nuchæ sclerotisans (Ehrmann).

Acne keloid is an inflammatory disease characterized by nodules, tubercles, pustules, with a tendency to ulceration, keloidal scarring, and excrescences. It is located back of the neck below and within the lower hairy boundary of the scalp. The nodules are frequently seen as small acneiform lesions which on close inspection are seen to be solid growths. They may be discrete, grouped, or in close clusters. They may vary in size from a small pea to a walnut and sometimes are known to grow as large as an orange. In color they may be pale pink in the white race; in the negro they are somewhat lighter in shading than the skin, or pinkish black.

The nodules are firm and hard to the touch and cut under the knife like bromatous tissue. Occasionally the surface of the lesion is excoriated, with an oozing and crusting presenting a granular appearance which has an offensive odor.

Some of the lesions are pustular and upon puncture the amount of pus expressed varies; usually it is far more than is found in an ordinary sycosis pustule. In fact abscesses develop under these lesions and are seen to pass deeply into the suboccipital and cervical interstitial tissues.

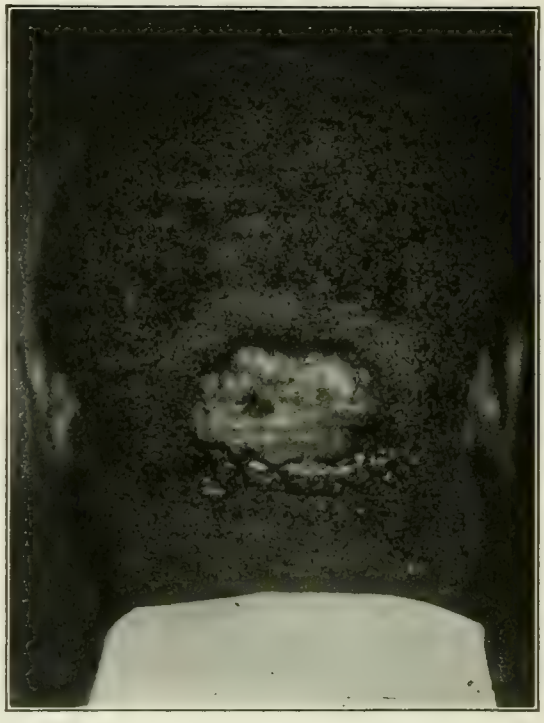

Fig. 1655.—Dermatitis Papillaris Capillitii in a Negro. (Case of Dr. H. W. Stelwagon.)

The disease is really an inflammatory condition not only of the skin but of the subcutaneous tissues as well and from the fact that it is located in the nuchal region, one of its long designation, has its origin. The inflammation is certainly connected in some way with the hair follicles and probably due to an infection of some type, but whether the process begins in or around the follicles or in the cutis is still a question.

Clinically one of the characteristics is the peculiar appearance of the hair. Some of the hairs are grouped in bunches having a stumpy and chewed-off appearance. Some of them grow stunted and ill-shaped upon the nodules or tubercles and are firmly imbedded. Other of the nodules are perfectly smooth, denuded of hair and follicles.

The disease is more apt to be seen in the negro, neither sex is exempt, and it occurs in young adult or middle-aged individuals.

Treatment.—The disease is difficult to cure. There is no tendency to spontaneous disappearance and it is frequently impossible to make any impres-

sion upon it. The small nodules may be removed by the electrocautery, by electrolysis, or by excision. If this is done it is well to follow it immediately with the *x*-rays, or the latter may be valuable used alone. Fuming nitric acid punctured into the lesions is an aid. If the growths are papillomatous and oozing, a soothing lotion made of boric acid or ichthyol, or an ointment made of the same, may be used.

If there are pustules present it is best to puncture them, and treat surgically. ROSE HIRSCHLER.

**Dermatitis Papillaris Maligna.**—Paget's disease of the nipple. See under *Breast Diseases of*, vol. ii., p. 488.

**Dermatitis Papulosa.**—Papular dermatitis is marked by the presence of numerous papules irregularly developed over the affected skin. They usually possess areolæ, which, if coalescing, produce a generalized inflammation. Exceptionally a papule may arise independently of an areola. Papules *per se* seldom coalesce as do vesicles or bullæ. They may vary in size from a pin head to a small pea; in shape they are flat, rounded or acuminate; in color they are more often a rose-pink. Papules may be seen occasionally surmounted by a tiny vesicle; upon section there may be found a small vesicle within not seen upon the surface.

Microscopically, the papule is produced by a slow exudation of serum into the skin in small areas. The capillaries and the lymph spaces become engorged, the connective-tissue elements become edematous as well as the rete mucosæ cells. There is an exudate of leucocytes and other inflammatory cells. If the inflammation is violent a small vesicle may develop somewhere within the papule, or be seen surmounting it.

The resolution of a papule occurs through an absorption of the serum, which, however, may be slow. There is also probably a migration of the leucocytes back into the blood-vessels and at the same time a resolution of the cellular infiltration. Often the papules are attended with intense itching and if so they will become excoriated and be associated with more or less crusting.

Because of a persistent, moderately severe, exciting cause, the dermatitis may remain regardless of treatment. Under such circumstances the skin becomes thickened and scaly with the itching more or less persistent. ROSE HIRSCHLER.

**Dermatitis Repens.**—This disease was first described by Crocker in 1888 from three of his own cases. Since then it has been observed by others, and though not rare it is an uncommon disease. Crocker defines dermatitis repens as a spreading dermatitis, usually following injuries, commencing almost exclusively in the upper extremities.

ETIOLOGY.—The cause is commonly some traumatism which may be a prick from an instrument, fish bone, etc. It has been found to follow shortly after a surgical wound or after healing upon the scar tissue. It is believed that it is due to a peripheral neuritis followed by a parasitic infection, neither of which suppositions has been proved.

SYMPTOMS.—The disease usually has its source in one or more vesicles or a bulla at the site of the injury. This location may be on the finger, the hand, or any part of the arm, but it usually is on the upper extremity. The bulla or vesicle ruptures sooner or later, permitting the escape of its contents. The floor of the vesicle remains more or less moist, raw, and red looking; while the broken epidermis collapses and tears, but still adheres at the outer edge. The exudation continues at the periphery forming an infiltrated and somewhat raised boundary, continuously undermining the epidermis, spreading the lesion. This undermining may or may not continue indefinitely. Often the lesion remains small and heals without much difficulty. Other instances have been known in which the disease has spread from the entire distance of hand to shoulder around the neck and down the other arm, as described in one of Crocker's cases. Such enormous extension is fortunately rare.

The edges of the epidermis not torn away from the lesion remain opaque and water-saturated, making one of the characteristic phenomena of the disease. As the disease extends peripherally the central area heals with a thin, shining, parchment-like, atrophic epidermis. Occasionally is seen, very near by, a vesicle which soon coalesces with the original lesion. The disease is not noted on parts of the body other than that of the original location.

Crocker speaks of a "dry" form in which the central area has little or no moisture present, but is shiny and red. The undermining edges are present, but the epidermis is dry and ragged. The disease may continue for from weeks to years, in spite of which life is not jeopardized. There is a tendency toward a recurrence.

PATHOLOGY.—In considering the pathology of the disease, one must believe that at least a serious involvement of the upper layers of the corium has taken place and probably that of the epidermis because of the apparent inability of the tissues to renew themselves normally.

DIAGNOSIS.—One observing carefully the description of this disease would scarcely take it for any other dermatological condition. It is said to have been confused with eczema. Eczematous disease is not developed by peripheral extension only, but also may be found on any part or involve the entire body; it is not of purely local origin; nor has it the peculiar undermined ragged edges of epidermis of dermatitis repens and does not heal with a tendency to atrophy.

TREATMENT.—It is best to incise the vesicle, trim off the dead epithelium, and then paint carefully with a disinfectant. Crocker recommends a ten per cent. solution of permanganate of potassium, used once daily for a week; a black crust forms which can be detached in a few days. Iodoform rubbed into the part has been effectively used. Silver nitrate solution and acetate of lead have been recommended.

In the dry form, Crocker suggests the application of Unna's salicylic and creosote plaster to the border to soften it, this to be followed by a compress of 1 in 4,000 bichloride solution to irritate the part, after which an ointment of boric acid should be employed to heal it. This should be done until the border is destroyed. ROSE HIRSCHLER.

**Dermatitis Rimosa of the Toes.**—This name has been given by Castellani to a condition from which white persons very often suffer in the tropics. It consists of an irritation and inflammation between and on the toes, characterized by itching, scaling, and fissuring, particularly the last. The trouble usually subsides on removal to a cool climate. While in the tropics the sufferer should by all means wear sterilized white socks frequently changed, and, if his occupation permits, roomy white canvas shoes outdoors and open sandals in the house, all soles to be of leather, not rubber. He should bathe the feet twice daily, using a carefully selected non-irritating soap and avoiding scented toilet soaps. After the bath the feet should be immersed once daily in a one-half per cent. solution of carbolic acid for a few minutes. After this, any fissures should be covered with zinc oxide ointment and the whole affected area copiously dusted with equal parts of bismuth subnitrate and zinc oxide. J. F. LEYS.

**Dermatitis Seborrhoica.**—Seborrhoic dermatitis, though sometimes called eczema seborrhoicum, is not an eczema at all. It begins upon the scalp in the form of a pityriasis or dry dandruff, which may remain in this state or develop into heavier masses of scales, forming what was formerly called "*seborrhœa sicca.*" After the disease has lasted some time upon the scalp, the hair becomes dry and brittle, loses its luster, and finally atrophies and falls, producing partial or complete baldness. In some cases the eruption is distinctly oily in character, and the scales become agglutinated and form greasy crusts which adhere to the scalp. Beneath these is a red, smooth, moist surface which itches or burns slightly. The course of the disease is extremely variable, but sooner or later it spreads from the scalp to other parts sometimes remote, but often contiguous. In a more inflammatory form the disease spreads beyond the hairy border of the scalp, extending down on the forehead and temples and around the ears. This consists in an infiltrated, dull, yellowish-red band or patch of eruption with a sharp, slightly irregular outline and covered with yellowish, greasy crusts. In the lobes of the ears and the external auditory canal these dry into more or less thick flakes, which can be removed with the fingers, leaving only a superficial moist, red patch behind. Scaly, red patches appear in the eyebrows; and the central region of the face, base of the nose, alæ nasi, and the adjacent portion of the cheeks soon become involved in the process. Here the affected skin presents a rough, red, oily character which becomes more evident when the face is heated. As a rare condition the vermilion border of the lips is affected, resulting in great swelling, pain, and thick crusting. The beard and moustache rarely escape, the same red patches covered with greasy crusts being scattered through them.

Other favorite locations for the eruption are the front and back of the chest, especially between the scapulæ, in the axillæ and groins, and around the umbilicus. It may also occur on the arms and legs and in some cases spreads generally over the body.

On the chest and back the eruption consists of macules and discrete papules, dull red in color and slightly scaly, which slowly enlarge to form plaques or patches of various sizes. As these grow at the periphery, involution takes place in the center, forming circular or circinate lesions, which by joining others form gyrate or festooned figures. This is the "*seborrhœa corporis*" originally described by Duhring.

In the axillæ and groins, and around the umbilicus the eruption generally occurs in the form of a sharply defined, yellowish-brown, slightly infiltrated patch which may become inflamed and crusted, resembling very much patches of ordinary eczema. Itching in seborrhoic dermatitis is not a marked symptom. Patients rarely complain of it except in warm weather, when they perspire freely.

When Unna first described this disease in 1887 he included many forms of eczema and even certain types of psoriasis under this name, but these generalizations have not been fully accepted. The best observers confine the title to the well-recognized types here described.

The disease is generally easily recognized. The chief reliance in diagnosis should be placed upon the seat of development, the method of progression, and the definite localizations of the disease, as well as upon the clinical appearances exhibited. The dull-red or yellowish-brown patches of crescentic or circinate outline, upon which soft greasy crusts form, can rarely be mistaken for ordinary eczema. In infants it lacks the symmetrical character and history of beginning on the cheeks and is never so inflammatory. From eczema intertrigo the differential points have already been given. The scales of psoriasis are dry and silvery white in color, the patches are more circular, and the localization of the eruption is different from that of seborrhoic dermatitis. Some cases of psoriasis, however, resemble dermatitis seborrhoica very closely; in these the history and course of the disease will help to clear up matters.

That seborrhoic dermatitis is a parasitic disease is now pretty definitely established. Unna originally found diplococci in the lesions and several varieties of bacilli. One, which he called the "*morococcus,*" he considered of special importance. He was unable, however, to reproduce the disease, but, through the bacteriological studies made by W. H. Merrill in 1895, Unna's findings were corroborated, and inoculation experiments were successful. Researches by Sabauraud and others in recent years are more of a scientific than practical interest, and a discussion of them is not called for in a work of this kind.

The *treatment* of the disease is not difficult. The most effective remedies are sulphur, resorcin, beta-naphthol, white precipitate, and nitrate of mercury and also the bichloride. The biniodide and red oxide are likewise very effective in some cases. Upon the scalp a lotion of resorcin, of a strength of from three to six per cent. in equal parts of alcohol and water, acts promptly.

Sulphur, however, either alone or combined with resorcin, is the most reliable remedy we have. It may be used in an ointment containing five per cent. sublimed sulphur and two or three per cent. resorcin, or the resorcin may be used in a lotion, as already mentioned, and once or twice a week a five to ten per cent. sulphur pomade may be applied to the scalp. This should be done at night and the ointment washed off in the morning. A lotion containing gr. ij. bichloride, ℥i. resorcin, ℥iss. chloral hydrate, and ℥iv. alcohol, is also extremely effective.

On the body a three or four per cent. resorcin ointment, or a mild sulphur ointment, will generally remove the trouble quickly. Beta-naphthol in five-per-cent. strength, white precipitate five to ten per cent., and the nitrate of mercury in the same strength, in ointments, are all good and effective remedies. The biniodide may be used with the white precipitate ointment in the proportion of one or two grains to the ounce of a five per cent. salve. The ointment of red oxide of mercury and sulphur referred to under the treatment of eczema will be found of great service in this trouble. About the genitals in infants care must be taken not to use the remedies in too great strength.

HENRY H. WHITEHOUSE.

**Dermatitis Skiagraphica.**—X-ray dermatitis; Röntgen-ray dermatitis. This may be defined as an inflammation of the skin, the early characteristic of which is an erythema; in certain instances attended by swelling, oozing, crusting, and later followed by atrophy, scarring, and telangiectases. In the more severe type of burn there may be ulcerations, sloughs and gangrene. Itching and excruciating pain are accompanying symptoms. The disease is difficult to cure.

*Erythema* is the mildest type of inflammation produced by the *x*-rays. It is usually preceded by a period of latency of several days and appears slowly on the area on which the rays have been applied. It should be recognized by the persistent, dark red flush, and is often accompanied by itching and burning, with a sensation of dryness; it may disappear in a few days; be recurrent; or remain with fine scaling. Erythema, scaling, pigmentation, and atrophy were common sequences observed on the hands particularly of the early operators, from the heedless handling of the light. Scarring from ulcerations, with immobility of one or more joints, should be added to complete the picture.

The mildest erythema may not be productive of serious symptoms but the danger is that the burn may be more deep and then it will be accompanied by ooz-

ing and crusting, followed by excoriations. The oozing is due to an exudation of a yellowish, sticky serum, which forms a crust. A prominent characteristic of *x*-ray burns is the pronounced pain. Except in the mild type healing occurs with scarring. A feature of interest is the soft, brilliant, pinkish white scar with stellate etching of newly formed capillaries. Sometimes instead of a thin scar a thick, keloid one is seen which is often the cause of contractures.

A still deeper burn is shown by formation of ulcerations. The ulcerations are more or less superficial but may be very deep indeed, followed by great sloughs and gangrene. The smaller ulcerations are rather shallow, covered by a diphtheritic looking membrane, or contain a very adherent, tough slough. They are persistent, do not heal spontaneously and may remain for months regardless of treatment. Great pain is also a constant feature.

There are some effects on the skin which, strictly speaking, have not been the result of a dermatitis *per se* but which are rather due to the peculiar insidious effect of the *x*-ray light. They are as follows:

*Atrophy* of the skin is seen frequently upon the face after the treatment for acne. Fine lines and premature wrinkles are produced; slight scaliness and dryness may be an accompaniment. The tips of the fingers atrophy, become shiny, and may be more or less scaly. The nails atrophy, become striated or have areas of thinness; they become brittle and break very easily; they may shed rapidly and if they are renewed they are distorted and unhealthy.

*Hair loss* may occur suddenly, a large bald spot appearing in twenty-four hours; or there may be a generalized, slow hair-fall. The facility with which hair-fall has been produced has led to the use of the rays as a depilatory for hirsuties. Here occasionally this has been of permanent value, but more often there is at least some renewal of the hair. When acting as a depilatory the rays cause the hair follicles to become more or less atrophied, permitting the hair to be easily removed with forceps; as a whole, the abundance of growth is reduced.

*Pigmentation* is usually found as a light or a dark brown freckling; or a general darkening like a bronzing of the skin. *Dryness* of the skin is probably the result of an atrophy of the sweat and oil glands.

Prevention.—In 1895, Prof. Röntgen, while studying various electrical effects through a Crookes tube, found the peculiar unknown light which he designated as *x*-rays. From the date of the discovery, the mechanism for the production of the rays has been wonderfully developed. Apparatus is found in the physicist's laboratory in the high grade schools, so that even children learn to know somewhat of the unknown quantity. But what they cannot appreciate are the stories of the men who have stood endless suffering from burns; who have undergone amputations and, still worse, have given up their lives, all in ardent research work before there was much knowledge as to the *modus operandi* of the light.

We now know that these sloughing masses due to deep burns and the dermatitis itself may be prevented by the following careful methods:

*For the patient:* 1. By the proper protection of the patient with lead foil; by enclosure of the tubes with a lead glass shield permitting only a sufficient opening for the required amount of rays to pass through; by filtering those rays that are permitted to pass, through an aluminum plate with or without an additional filter of water-soaked calf leather.

2. By the quality of tube used. A hard or a high-vacuum tube produces penetrating rays; a soft or low-vacuum tube produces slightly penetrating or surface rays. A medium tube produces a moderate amount of penetration and is the best one to use for therapeutic purposes in dermatology. The very soft tube is the one most likely to cause burns.

3. By regulating the amount of current used.

4. By the distance of the anti-cathode from the patient which should be from ten to twelve inches, until the tolerance to the rays is established.

5. By the length of the seance, which ordinarily should be from a few minutes to five or ten.

6. By infrequency of treatment which should be determined upon by the patient's reaction.

On the first appearance of an erythema, the rays should be discontinued and should not be repeated until the erythema has completely disappeared. The mental reservation should be made that an erythema is the danger signal, and that there is a period of latency before its appearance.

*For the operator:* 1. He should be protected most carefully, for he is longer exposed by daily continued operations and observations than is the patient. He should be an adept in the knowledge of the mechanism of the instruments and the tubes.

2. He should operate the machine in a nearby room beyond a closed door, lead-protected if need be, and containing an observation window. Switches and wire extensions can be used in the operating room to facilitate action and to prevent unnecessary migration into the charged atmosphere.

How the light produces a dermatitis or is therapeutically effective is still under conjecture. One of the great operators believed that the electrical effleuve from the coil had much to do with the operator's burns. If one with a sensitive skin stands near an active coil the skin will tingle and feel dry and irritable even for some time after emergence from the induction field. The belief that particles of metal from the anti-cathode is a causal factor has passed by. The period of latency before an erythema becomes manifest seems to represent a period of absorption of the rays, a cumulative period. Some one has formulated a rule that the period of latency is in inverse ratio to the intensity of exposure, while the time of reaction is in direct ratio. Be that as it may, there is a devitalization of tissue in which the reparative changes are defective and which may result in final degeneration as necrosis and ulceration. This appears to be peculiar in that the degeneration is greater than that produced by the rays *per se;* also, that while the devitalizing process is going on in certain areas, in the surrounding areas stimulation is taking place to further reparative work. The pathologically altered cells are less resistent to the rays' action than are normal cells and so are the more highly differentiated structures such as hair follicles, glands, nails, blood-vessels, etc.; therefore, diseased cells and these specialized organs are more readily and severely burned than are the less differentiated epidermal cells or fibrous stroma of the corium. Ulcerations may be so long persistent that carcinoma develops on their site. The ulcerations and the sloughing may necrotize through skin, and muscle, down to the bone. Some observers believe that the condition is a trophoneurosis of centric origin during the period of latency subsequently becoming centrifugal in its manifestations (Stelwagon). One feasible explanation of the defective repair work is because of the immediate injury to the blood-vessels themselves (Behrend).

Treatment.—Obviously the best and easiest method is to avoid the burn. In the mild or moderately severe types the remedial agents in acute inflammation will be serviceable. The difficulty of treatment is with the deeper and severer burns, especially the ulcerative lesions that are prone to be obstinate and unyielding. Under such stress it is probably the best treatment to curette and follow with skin grafting. Previously it is often necessary to use soothing ointments for the burns. Menthol, resorcinol, acetanilide, orthoform, cocaine, opiates, etc., have been recommended.

Rose Hirschler.

**Dermatitis Venenata.**—Under this term are included those dermatoses which are due to immediate or indirect contact with animal, vegetable, or mineral substances.

It is a dermatitis characterized by erythema, wheals, papules, vesicles, pustules, bullæ, or a combination of two or more of them, with an addition of crusting and excoriations. Of the vegetable substances causing dermatitis venenata possibly *Rhus toxicodendron* (poison ivy), a climbing plant and a small tree or shrub (poison oak) are the most common in the eastern part of the United States, and also in the West. In the Middle States the poison sumac seems to be the more commonly poisonous one *Rhus venenata* (poison dogwood, poison sumac, poison elder). The nettle, commonly seen in the woods and unkept meadows, the primrose (*Primula obconica*), the oleander (*Nerium oleander*), the rue (*Ruta*), the smartweed (*Polygonum punctatum*) are the most common ones known, but there are many others too numerous to mention.

The inflammatory reaction produced by *Rhus toxicodendron* is quite typical and so commonly seen in the springtime and summer that even the laity may make an accurate diagnosis. The disease starts upon the exposed parts primarily. The hands and wrists or forearms are the first members attacked usually, then follow the face, the genitalia, and anal regions; barefooted children are great sufferers also. It is said that toxicodendric acid, a volatile substance, is the cause, although it has not been specifically proved. Many persons who have had at one time or another severe attacks, have found that in passing through the woods, or anywhere in the proximity of the plant, they may have a recurrence of the attack, even though the plant is not touched. The writer has personally verified this, but she finds as the years pass and there has been no contact made with the ivy, the peculiar susceptibility to the air-laden poison becomes almost nil. There is a belief that after one attack of some severity there is a recurrence at the same time the following year, regardless of any proximity to plants. The writer scarcely believes this. Probably these are cases of vesicular eczema. There is a serious tendency in some instances to a persistency toward a chronic condition, which, according to our present status of eczema, may be classed as such. Those patients who are prone to attacks of eczema are very susceptible to the poison.

There are individuals, too, who from childhood have never been subject to plant poisoning, but with change of climate or methods of living, suddenly are rendered susceptible. Then there are those who seem to preserve an immunity to poisonous plants, handling them with perfect impunity.

Quoting from Dana's "How to Know the Wild Flowers," "the poison ivy is a shrub which usually climbs by means of rootlets over rocks, walls, and trees; sometimes low and erect." Leaves "are divided into three somewhat four-sided pointed leaflets. . . . . "This much dreaded plant is often confused with the beautiful Virginia creeper. . . . . the two can be distinguished by the three-divided leaves of the ivy and the usually five-divided leaves of the creeper." Dana also says that the ivy is reputed to be especially "harmful during the night, or at any time in early summer when the sun is not shining upon it." It is well to know the plant from its neighbor, for no sufferer would have the hardihood to face anew an attack when unnecessary.

*Symptoms.*—A more or less mild attack may be ushered in by a burning or an itching of the skin. Within a few hours up to twenty-four or forty-eight, an erythema may appear followed by swelling, with vesicles; or the vesicles may arise with little areola. The vesicles may be few in number, or clustered in great multitudes on the affected parts. They may be very tiny or vary in size from a split pea to large bullæ. At first they may be tense but often rapidly become flaccid, rupturing easily. The yellowish serum in the vesicles doubtless carries the poison, as it seems to inoculate nearby previously unaffected areas, spreading the disease. The lesions often develop in streaks or stellate patches slightly raised and erythematous, surmounted by vesicles; and sometimes the entire impress of a leaflet is found on inspection. The parts may swell to enormous proportions. The face becomes quite distorted in shape beyond recognition. The eyelids suffer, and conjunctivitis is not uncommon.

Fig. 1656.—Dermatitis Venenata. (Case of Dr. Stelwagon.)

The suffering from the itching and burning is intolerable. A curious sense of relief comes from puncturing the bullæ and scratching, when crusting necessarily follows.

Staphylococcus infections are very common in the clinic type of patients. Rarely gangrene occurs, but usually when it does it is in very small areas.

Some general symptoms may arise during the progress of the eruption. Nervous symptoms from the suffering are common, and rather rarely there is a chill followed by fever of 101° to 102° F. with rapid pulse and prostration.

The dermatitis usually progresses to a certain point before regression takes place. Some abortive cases clear up rapidly. Treatment may relieve very greatly the itching. After the vesicles rupture and dry the

erythema and swelling slowly disappear and the skin desquamates in more or less large pieces. The disease may last but a few days or remain from several weeks to several months. Its common duration is from ten days to three weeks. If it lasts for two or three months, it has passed on to a so-called eczema. Rhus dermatitis often leaves in its wake a mass of freckles or pigmentation such as so often follows a sunburn.

The rash from grasping a *nettle* is usually not so diffuse on the body as that from the poison ivy. One ordinarily must come in contact with the nettle to become affected. The stinging of a nettle as it rubs

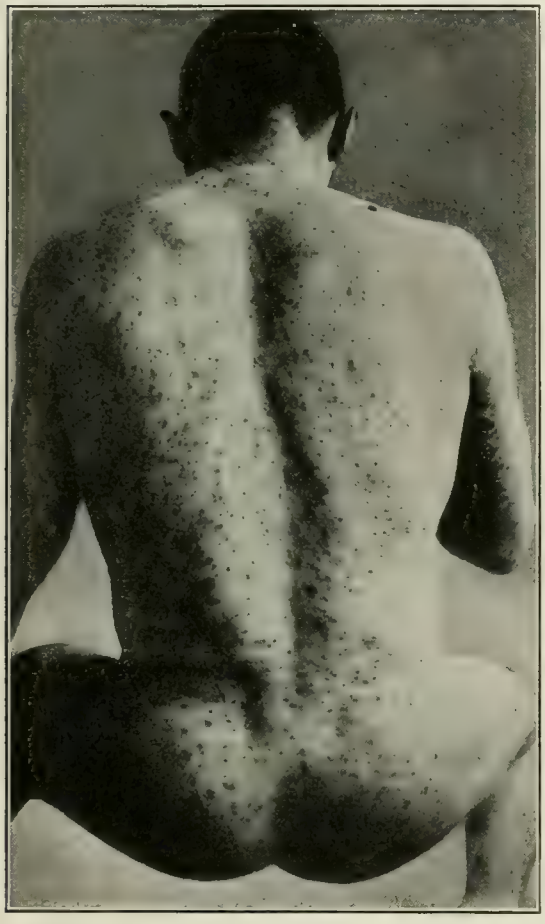

Fig. 1657.—Grain Itch. (After Schamberg.)

over the skin is almost intolerable to a sensitive person. The parts touched become red and sometimes swollen and, but not always, covered with fine vesicles. The lesion heals in a few days.

As to the *primrose*, in America the horticulturist knows well its poisonous nature of which the laity is usually ignorant. Many florist shops will not sell the plant. The hands seem to be the parts most quickly affected, and particularly by the person who cares for the plant. There may be a simple erythema, or erythemato-vesicular lesions of the eczematous type, or an erythema bullosum. The bullæ may become very large, extending the lesion by contiguous inoculation. A red urticaria may simply result. It is said that the irritation is caused by the hairs of the plant.

*Treatment.*—In treating dermatitis venenata the large vesicles or bullæ should be evacuated, an effort being made to keep the secretion from touching other parts. Compresses of boric acid or phenol lotions may be used, or a solution of thiosulphite of soda. Lotions with powder suspensions are comforting; Schamberg recommends a compound resorcin lotion containing boric acid and resorcin, āā ℥i.; pulv. zinci oxidi, ℥ii.; aq. calcis q.s. ad ℥viij. In this may be incorporated sodium thiosulphite ℥ss. to ℥i. The writer likes to use the lotion with oleum gossypii ℥ii.–iij. in Aq. calcis q.s. ad ℥iv.–℥vj.; this makes a comforting mayonnaise-like dressing. If the rash is profuse tub-baths containing baking soda or, better still, washing soda in solution are delightfully comforting. From one-half to one pound to the tub is not too strong. Many use salt baths or salt compresses. Hot compresses of salt and baking soda solution are helpful. In mild cases healing may be obtained by a simple astringent ointment such as unguentum, zinci oxidi, but ointments as a rule are not so pleasant as lotions.

Insects.—Every one knows the irritant action of *stings of insects* as bees, wasps, blue-bottle flies, spiders, etc., how they produce a painful swelling, and if very virulent may cause a slight slough at the point of puncture of the sting. If the insect has been feeding on some putrid material prior to the bite, the inoculation may become deadly in its nature. The caterpillar is another nuisance. There are a number of varieties some of which produce very serious symptoms. The long, fine hairs are supposed to be the irritants.

*Grain itch* "is an eruptive disorder characterized by a widespread urticarioid eruption, accompanied by intense itching, and due to the noxious activity of a small mite, the *Pediculoides ventricosus*" (Schamberg).

This affection was first clinically studied and described in this country in 1907–1909 by Dr. Jay F. Schamberg. Dr. Joseph Goldberg of the U. S. Public Health service together with Schamberg found the pestiferous mite.

The writer had the pleasure of seeing many of the cases with Dr. Schamberg at the Polyclinic hospital and can confirm the notes which she has taken freely from his article on the subject. The mite is parasitic upon "wheat, barley, and other cereals and the straw therefrom."

The afflicted individual must come into direct contact with the incriminated straw, as farmers in the field or in the granary, or indirectly through a material covering the straw, as sacks of grain, mattresses, etc. The lesions are due to the toxic bite of the insect.

They usually consist of urticarial, rose-pink wheals, surmounted by pin-point vesicles, which first contain clear fluid but rapidly become purulent. They may look very much like a varicella vesicle. The efflorescence may vary from a barely elevated erythemato-urticarial spot or papulo-urticarial lesion to a frank wheal. The papular lesions are usually edematous. They may be one to two millimeters in elevation, and may be round or multiform.

The itching is very intense, so that excoriation and crusting add to a typical picture. It is worse at night. The eruption is usually profuse upon the back, chest, abdomen, and more scant upon the extremities and face, while the hands and feet are free.

Rarely the eruption is a macular erythema multiforme or scarlatinoid. There may or may not be prodromal symptoms such as malaise, rise of temperature, anorexia, and vomiting. There may be a mild albuminuria, slight leucocytosis, and eosinophilia.

New lesions persist in coming until the cause is discovered and removed. After this is done the skin should be free in a week or two.

It must be differentiated from simple urticaria by the persistence of the lesions, by the vesiculation and the apparent epidemicity in the individual's home. From chickenpox by the size of the vesiculation, the

duration of the lesions, and its lack of prevalence in children. From scabies by the absence of the burrows, the freedom of the hands, and the uniformity of the eruption. From pediculosis corporis by the presence of vesicles and absence of the pediculi.

The treatment, for permanency of cure, of course is to remove the infected mattress or what-not, and the garments next to the skin; hot baths to rid one of the parasites which may be migrating upon the skin. The most effective ointment is one of beta-naphthol, gr. xxx.; sulph. precipitat., gr. xl.; adipis benzoat., ℥i.

Drugs commonly used externally as medicinal agents are productive of dermatitis, some purposely and others unwittingly creating the disturbance. Used as an application over open surfaces as wounds, ulcerations, etc., they may become absorbed and produce a rash elsewhere beside the inflammation at the immediate site of application. Walker says that many of the drug rashes are "curiosities" of "idiosyncrasy on the part of the patient" or "they would otherwise be much more frequent."

Turpentine, mustard, belladonna, croton oil, cantharides, iodoform, arnica, chrysarobin are but a few drugs known to produce a rash.

*Mustard, turpentine* and *belladonna* all induce an erytheme, but may cause vesiculation.

*Croton oil* and *cantharidis* may produce violent vesiculation.

*Iodoform* not uncommonly starts a local inflammation which may spread rather rapidly beyond the dressed wound. This is said to be more particularly true of the dry powder. It is often absorbed and causes eruptions on other parts of the body. The lesions may be erythematous, or an erythema with vesiculation. There may be considerable swelling or edema. It may be very rebellious and tend toward chronicity. If often simulates erysipelas.

*Orthoform* acts similarly to iodoform but may produce small areas of gangrene with the vesiculation.

*Tincture of arnica,* in common usage years ago, may cause a dermatitis simulating erysipelas so perfectly that only the history enables the diagnosis to be made clear.

*Chrysarobin* causes an inflammation and discolors the skin at the same time to a dusky red or a purplish hue, which seems to spread to a considerable area beyond its application.

*Arsenic* may produce a vesiculo-erythema, as well as other peculiar dermatoses, including gangrene. A persistent ulceration of the finger is spoken of by the French writers.

There are trade dermatoses produced by drugs used in certain trades as aniline dyes in manufacturing wall papers, dyed material for clothing; aurantia used in staining cheap yellow shoes (Crocker); etc.

*Bichloride of mercury* is a serious menace to the work of many of our hospital internes and nurses who are made to immerse their hands repeatedly in a solution. It is usually erythemato-vesicular, with sometimes severe fissuring, and may appear in places quite distant on the body as in the axillæ, over the abdomen, or on the thighs. The itching and burning are severe. It is often so persistent after using the solution as to render the patient unfit for work if use of the drug is persisted in. Rose Hirschler.

**Dermatobia.**—A genus of bot flies, *Oestridæ.* The larvæ of *D. cyaniventris* live beneath the skin of man until they mature; they are then discharged and pupate on the ground. These insects are found in all the countries of Tropical America. See *Insects, parasitic.* A. S. P.

**Dermatol.**—The trade name for the subgallate of bismuth, $BiC_7H_7O_7$ containing fifty-five per cent. of the oxide of bismuth. It is a fine, yellow powder, devoid of odor, quite insoluble in water or any of the ordinary solvents, free from irritating action, and non-poisonous.

It was introduced to replace iodoform, on account of its freedom from many of the disagreeable qualities of that drug.

Its action is that of bismuth with a slightly additional astringency. It is very serviceable in burns, scalds, ulcerating surfaces, acid, eczematous conditions, on account of its astringent and soothing properties.

It may be applied by dusting on the part, or in the form of an ointment of one part in ten. It may with advantage replace oxide of zinc, starch, etc., as a dusting powder for scalded and denuded surfaces. In chronic gonorrhea the following emulsion has been used with success: Dermatol, 2; gum acacia, 2; distilled water, 25 parts.

In doses of gr. xxx to xc it has been given internally, as a substitute for the subnitrate, for diarrhea in children, in phthisis, typhoid fever, etc., with good results.

*Airol* is a subgallate of bismuth to which iodine has been added to the extent of about twenty-five per cent. Beaumont Small.

**Dermatolysis.**—See *Cutis Elastica and Cutis Pendula.*

**Dermatophilus.**—A genus of fleas, family *Sarcopsyllidæ,* which contains *D. penetrans,* the chigoe or jigger. The male and female chigoes live in sandy soil and are very active. They live by sucking blood from warm-blooded animals. After impregnation the female burrows beneath the skin of some animal and her abdomen swells to the size of a small pea. The eggs are passed through a hole in skin and the female is later expelled by ulceration. Sometimes the loss of a toe or leg, or even tetanus, results from the sores caused by these insects. See *Insects, parasitic.* A. S. Pearse.

**Dermoid Cysts.**—See *Cysts.*

**Dermol** is a name given to the bismuth salt of chrysophanic acid. It is an amorphous, yellow powder, and is supposed to possess the properties of bismuth and chrysarobin; it is used in various parasitic skin diseases. R. J. E. S.

**Desault, Pierre-Joseph.**—Born in Magny-Nernoie, France, February 16, 1744. Although destined by his parents to enter the service of the church, Desault soon discovered that he was better fitted to pursue the career of physician; and accordingly, in 1764, he went to Paris, after vainly endeavoring to secure satisfactory medical instruction in the military hospital at Belfort. Under the teaching of such masters as Louis, Morand, and Sabatier, he made satisfactory progress, and soon succeeded in securing pupils in anatomy and surgery. Although very poor, he was able, through the generosity of Louis, to obtain the right to deliver lectures at the École-Pratique. Being of an inventive turn of mind Desault devised, at about this time, certain surgical procedures which helped greatly to spread his reputation. Thus, for example, he proposed a new and more efficient form of bandage for the cure of fractures of the clavicle; he introduced the practice of using a straight instead of a curved knife in the operation of amputating a limb; he advocated the immediate application of ligatures to the divided ends of the arteries after an amputation, a practice which had been abandoned since the time of Ambroise Paré; in the treatment of aneurysms he restored to favor Anel's method—which was known at that time, however, under the name of Hunter's

method—of ligaturing the artery above the tumor; and, finally, he improved the treatment of fractures of the neck of the humerus by employing a form of bandage which embodied the same principles as those which guided him in devising a new bandage for use in fractures of the clavicle. From this time onward Desault's reputation as a surgeon was as great as that which he had previously enjoyed as an anatomist. In 1782 he received the appointment of Surgeon-in-Chief of La Charité Hospital, and in 1788 he was given the same position in the much larger hospital of Hôtel-Dieu. Here he established the first thoroughly well-organized surgical clinic in France, if not in Europe.

It is not possible, within the limits assigned to this sketch, even to enumerate, much less to describe in detail, the many improvements which Desault inaugurated, during this period, in surgical methods of treatment. He died, June 1, 1795, at the early age of fifty-one, after an illness of only three days. He left behind him practically no writings, but Bichat, one of his pupils, has published a book which bears the title: "Oeuvres chirurgicales de Desault," Paris, 1798–1799; three volumes. In 1791 Desault's pupils began keeping a journal in which the master's teachings were recorded, and this, after Desault had himself revised it, was afterward published in four volumes. The record of his doctrines is quite complete.

A. H. B.

**Descemet, Jean.**—Born at Paris, France, April 20, 1732. He began the study of medicine in 1750 and received his doctor's degree in 1758. His inaugural thesis showed clearly that he had acquired habits of close observation and that he might with justice be ranked as a skilful anatomist. In the course of his career he held in turn the following positions of honor: Dean of the Paris Faculty of Medicine, Professor of Botany and of Anatomy, Royal Censor, member of the *Société royale de Médecine*, physician of the *Lycée impérial*, etc. He died at Paris, October 17, 1810.

Descemet's chief distinction is to be found in the fact that he is believed to have been the first to describe carefully the membrane which lines the internal aspect of the transparent cornea. Pierre Demours claimed that his discovery of this membrane was made at a still earlier date; but the consensus of opinion formed at that time seemed to be in favor of Descemet's claim of priority of discovery. Nevertheless, one finds in most text-books that the membrane in question is spoken of as Demours's or Descemet's membrane. The two published writings in which Descemet mentions this membrane bear the following titles: "An sola lens crystallina cataractæ sedes?", Paris, 1758; and "Mémoire et observations sur la choroïde," in *Mémoires des Savans étrangers de l'Académie royale des sciences*, vol. v., 1768. The latter treatise or memoir was read before the Royal Academy in 1760.

A. H. B.

**Desiccation, High-frequency.**—In 1911, Clark, of Philadelphia, described a method of destroying superficial neoplasms by rapidly desiccating the tissue through the agency of currents of high frequency. This method has been termed *oscillatory* or *high-frequency desiccation*.

The apparatus employed consists of a specially constructed twelve-plate static machine capable of 2,000 revolutions a minute when driven by a five horse-power motor and producing from 2.5 to 3.5 milliamperes. The current then passes to the high-frequency outfit composed of Leyden jars, each of a capacity of 0.00042 microfarads, and a resonator. The electrode has an insulating handle in which is placed a fine metal point about the size of a needle, while a mechanical device permits of make and break. According to the claims of Clark, the proper desiccation results cannot be obtained by using a coil in place of the static machine because the interruptions and irregularity of the discharge of the former make it impossible to maintain a uniform degree of heat during the application.

When treating superficial lesions one pole of the apparatus is grounded while the other is connected with the electrode, the metal point of which is held a short distance from the part and the sparks allowed to strike upon it through an open air space.

There follows an immediate blanching of the tissue if the lesion is dry, as in the case of a wart, or blackening if it is open with oozing blood. There is soon observed an area of inflammatory reaction around the desiccated mass. Repair takes place under the scab formed and is completed in from one to three weeks depending upon the extent of the destruction. When it is necessary to desiccate to a deeper degree, the bipolar method is used, a different electrode of large size being placed upon any part of the body, while the metal electrode is plunged into the tissue.

It is usually not necessary to employ a local anesthetic, as a few short sparks will suffice to destroy sensation sufficiently to allow of the application. It may be advisable, however, to use a solution of cocaine when treating nervous individuals, or where the part is hypersensitive.

When heat is applied to living tissue the effect varies, according to the degree used and the length of application, from a simple hyperemia to burning, and somewhere between these two extremes is a point where the heat is sufficient to dehydrate the tissue without burning. This has been called the desiccation point. Clark determines this point by projecting the sparks through paper upon a piece of soap. If the soap is dehydrated sufficiently to be readily pulverized between the fingers without charring or discoloring the paper the current is of proper strength to use and will desiccate tissue without burning.

Desiccation must not be confused with the other methods of employing high-frequency currents in similar diseased conditions, particularly the de Keating-Hart fulguration, destructive fulguration, and electrocoagulation. These methods are fully described in articles in other places in this work. It may be well, however, to point out the essential differences.

In the de Keating-Hart fulguration a cold spark of at least ten centimeters in length, obtained from a coil apparatus, is employed upon the site of cancer after all visible growth has been removed by surgical means. There is absolutely no destruction of tissue as a result of the sparking.

In destructive fulguration, or better, high-frequency cauterization, the current is obtained from a coil. While it is very similar to desiccation, it is claimed by Clark that the thermic degree is too high and the impact against the tissues too severe, and that there is produced carbonization instead of desiccation.

Electrocoagulation is the employment of a bipolar current of high amperage in which the growth is coagulated by the heat produced by the current.

Desiccation may be employed for the destruction of benign growths such as warts, moles, vascular nevi, the excessive granulations of chronic ulcerations, tattoo marks, *x*-ray keratosis, and lesions of similar character. The cosmetic results are usually good provided the desiccation has not been carried too far. The method has been used for removing benign growths from the bladder, but probably differs little

from high-frequency cauterization as reported by Beer, of New York, in 1910. Clark has reported some very interesting and encouraging results in the treatment of superficial lesions about the face and also of benign tumors of the bladder.

While desiccation has been used for the destruction of epitheliomata the writer believes it unwise to employ it as a routine measure in this class of cases; he believes in excision for all growths in which there is the slightest suspicion of malignancy, followed, where indicated, by some of the newer methods of treatment, if upon further trial the use of them seems of distinct benefit.

WORTHINGTON SEATON RUSSELL.

**Desmoid Tumors.**—(Desmoid, tendon-like.) This designation has been applied to that variety of hard fibroma which on section creaks under the knife, and shows a cut surface resembling more or less that of a tendon.

These growths form as a rule circumscribed tumors, varying in size from a mustard seed to a man's head or even larger; and are round, nodular, or lobulated. They usually possess a definite capsule, and grow entirely by expansion. Their consistence is very hard and firm. On section they show a white, glistening, tendon-like surface in which the whorled and interlacing bundles of coarse fibers of connective tissue are often visible to the naked eye. The cut surface is dry or but very slightly moist. Occasionally the color is pink or reddish. To the naked eye few blood-vessels are usually visible, but microscopically these growths may be found to possess a well-developed system of vessels. Occasionally the latter may become angiectatic, whereby the cut surface of the growth is mottled red and white.

The finer structure of these growths consists almost entirely of fibrous connective tissue, either arranged in coarse fibres or appearing almost hyaline and homogeneous. The intercellular substance far exceeds the cells in amount, the latter frequently being present in very small numbers and widely separated by the hyaline intercellular substance. In some portions of the growth the cells may entirely disappear, leaving only the hyaline intercellular substance, which eventually becomes calcified or undergoes liquefaction. Retrograde changes are very common in these growths: hyalin, calcification, necrosis, liquefaction following edema or myxomatous degeneration, gangrene, etc.

Desmoid tumors are found most frequently in the subcutaneous tissue, intermuscular connective tissue, nerve sheaths, retroperitoneal tissues, serous membranes, etc., in which regions they may reach a large size. Small growths of a similar nature occur less often in the mammary gland, parotid, and kidneys, and more rarely in the ovaries, liver, and spleen. Uterine myofibromata containing but a small proportion of unstriped muscle assume the appearance of desmoid fibromata. The so-called desmoids of the abdominal wall are in reality spindle-cell fibrosarcomata of slow malignancy, but differing from the fibromata in that they grow by infiltration. The true desmoid is malignant only by size, position, and tendency to necrosis. It does not infiltrate nor give rise to metastases. If removed with its capsule entire it will not recur.

ALDRED SCOTT WARTHIN.

**Des Moines, Iowa.**—Situated in the central portion of the State of which it is the capital, upon the Des Moines River. It is of considerable size and importance. Population in 1910, 86,368. The climate is indicated by the accompanying table:

CLIMATE OF DES MOINES, IOWA—LATITUDE, 41° 35′; LONGITUDE, 93° 37′; PERIOD OF OBSERVATIONS, FIVE YEARS, FIVE MONTHS.

| Data. | January. | July. | Year. |
|---|---|---|---|
| Temperature (degrees Fahr.)— | | | |
| Average or normal | 20.9° | 73.8° | 49.0° |
| Average daily range | 19.2 | 19.4 | |
| Mean of warmest | 29.4 | 84.7 | |
| Mean of coldest | 10.2 | 65.3 | |
| Highest or maximum | 63 | 98.5 | |
| Lowest or minimum | —26 | 52 | |
| Humidity— | | | |
| Average relative | 71.1% | 71.2% | 69.0% |
| Precipitation— | | | |
| Average in inches | 1.06 | 3.37 | 41.35 |
| Wind — | | | |
| Prevailing direction | N.W. | S.W. | S.W. |
| Average hourly velocity in miles | 6.3 | 5.1 | 6.4 |
| Weather— | | | |
| Average number clear days | 11 | 10.6 | 111.2 |
| Average number fair days | 11 | 14.2 | 151.3 |
| Average number fair and clear days | 22 | 24.8 | 262.5 |

EDWARD O. OTIS.

**Detmold, William.**—Dr. William Detmold, the son of Henry G. Detmold, Court Physician to the King of Hanover, was born in Hanover, December 27, 1808, and studied medicine at the University of Göttingen, where he was a pupil of the celebrated orthopedic surgeon, Stromeyer. He received his degree of M. D. in December, 1830. After serving

FIG. 1658.—William Detmold.

for a time as army surgeon in Hanover he came to America and settled in New York in 1837. He introduced the practice of orthopedic surgery as a specialty into this country, having established an orthopedic clinic at the College of Physicians and Surgeons in 1841. In 1862 he became Professor of Military Surgery and Hygiene there, and afterward Professor of Clinical and Military Surgery. He died of apoplexy on December 27, 1894.

Dr. Detmold was prominent in the organization of the Medical Corps of the United States Army in the earlier part of the Civil War. During a surgical practice of over half a century in New York he was Vice-President of the New York Academy of Medicine, Consulting Surgeon to the Presbyterian Hospital, the first President of the New York County Medical Association on its organization in 1884, and one of the founders and President of the Society for the Relief of Widows and Orphans of Medical Men. He was an occasional contributor to the medical journals

of the country, his first publication on orthopedic surgery appearing in the *American Journal of the Medical Sciences* in 1837. T. L. S.

**Dettweiler, Peter.**—This pioneer, with Brehmer, in the sanatorium treatment of tuberculosis was born at Wintersheim in Hesse, August 4, 1837. He studied medicine at Giessen, Würzburg, and Berlin receiving his medical license in 1863. He entered the medical corps of the Army, taking part in several campaigns in 1864–66, and the Franco-German War

Fig. 1659.—Peter Dettweiler.

in 1870–71. During the latter he contracted tuberculosis and went to Goerbersdorf to become an inmate of Brehmer's Sanatorium. He regained his health there, and after spending six years as patient, pupil, and assistant of Brehmer, he went to Falkenstein and founded a new sanatorium. Here he instituted a method of treatment radically different from that of his teacher in Goerbersdorf, for while the latter advocated walking and graduated exercises to strengthen the heart, Dettweiler insisted on rest in the open air (Liegecur) and dietetic treatment, and he also regarded climatic conditions, altitude, etc., as of secondary importance in the treatment of tuberculosis. In 1891 he founded another sanatorium at Rupertshain for the poor, and it was largely through his influence that the movement in Germany for providing gratuitous sanatorium treatment for indigent sufferers from tuberculosis was initiated and sustained. In 1903 failing health compelled him to retire to his villa at Cronberg, where he died a year later, January 13, 1904.

Dettweiler published many articles on the treatment (especially hygienic and dietetic) of tuberculosis, and read many papers on the same subject before national and international Congresses. His most important work was entitled "Die Behandlung der Lungenschwindsucht in geschlossenen Heilanstalten," of which three editions were published. See also the article *Falkenstein* in this Handbook.

T. L. S.

**Detroit.**—The chief city of Michigan, of 765,766 inhabitants (census 1910), is situated on the northern bank of the Detroit River, connecting Lake Erie and Lake St. Clair, and forming the boundary between the United States and Canada. The climate of Detroit is represented by the following chart.

Climate of Detroit, Mich.—Latitude, 42° 20′; Longitude, 83° 3′; Period of Observation, December 1, 1870, to December 31, 1883.

| Data. | January. | July. | Year. |
|---|---|---|---|
| Temperature (degrees Fahr.)— | | | |
| Average or normal | 24.8° | 71.6° | 47.9° |
| Average daily range | 12.7 | 18.4 | |
| Mean of warmest | 31.3 | 81.4 | |
| Mean of coldest | 18.6 | 63 | |
| Highest or maximum | 65 | 100 | |
| Lowest or minimum | −15 | 50 | |
| Humidity— | | | |
| Average or relative | 78.3% | 70.0% | 71.6% |
| Precipitation— | | | |
| Average in inches | 2.14 | 4.14 | 35.41 |
| Wind— | | | |
| Prevailing direction | S.W. | S.W. | S.W. |
| Average hourly velocity in miles | 8.2 | 6.4 | 7.8 |
| Weather— | | | |
| Average number clear days | 3.8 | 9.8 | 85.9 |
| Average number fair days | 9.6 | 14.9 | 147.8 |
| Average number fair and clear days | 13.4 | 24.7 | 233.7 |

Edward O. Otis.

**Dewees, William Potts.**—Born in Pottsgrove, Pa., May 5, 1768. He attended lectures in the University of Pennsylvania, and took the degree of Bachelor of Medicine in 1789. He at first practised his profession in Abington, a small settlement to the north of Philadelphia, but in 1793 he removed to the latter city. At that period midwifery, as a science, was hardly known in America, and it was to this department of medical knowledge that Dewees and one or two others began then to devote their attention very closely. In 1806 the University of Pennsylvania conferred on Dr. Dewees the degree of Doctor of Medicine; his thesis on this occasion being entitled: "The Means of Moderating or Relieving Pain during Parturition." In 1810 it was decided to establish a chair of midwifery in the university, and a warm contest took place between the rival applicants for the position—Dr. Dewees and Dr. James. The latter was the successful candidate. Fifteen years later, Dr. Dewees was elected to the position of Adjunct Professor of Obstetrics, and he remained in this secondary post until 1834, when he was elected to the professorship.

In 1826 he published a book bearing the title: "Compendious System of Midwifery." It was a good book and attracted considerable attention abroad. Three editions were issued during the following two years. Stone says of this book: "It was written at the time when Dewees's personal influence was unbounded and it wielded a sway over the opinions of his contemporaries and pupils which directed their practice and controlled their actions long after his death, and for this reason he may truly be regarded as the father of American obstetrics." He died May 18, 1841. A. H. B.

**Dextrins** are complex polysaccharide carbohydrates which are formed from starch by various methods of hydrolytic cleavage, such as boiling starch with water at a high temperature, boiling with an acid, or by the action of various types of diastatic enzymes. See *Aliment*. F. P. U.

**Dextrose,** $C_6H_{12}O_6$ (glucose, grape, sugar) is a monosaccharide carbohydrate, a simple sugar, deriving its name from its influence upon the plane of polarized light. It is the sugar present in the blood and may be formed from the cleavage of more complex carbohy-

drates. It is found in the urine normally in traces, while in diabetes the quantity present may be very large. See also *Aliment.* FRANK P. UNDERHILL.

**Dezeimeris, J. E.**—The principal author of the "*Dictionnaire Hisorique de la Médecine Ancienne et Moderne*" (Paris, four volumes, 1830–1839).* This great work contains biographical sketches of a large number of physicians who, from the beginning of the Christian era to the early part of the nineteenth century, have contributed something worthy of mention to medical knowledge. It also contains very full lists of their published writings. As librarian of the Faculty of Medicine of Paris, Dezeimeris had unusual facilities for obtaining full and accurate data upon which he could base these biographical sketches. But this great advantage, as he tells us in the Preface to Vol. III., did not entirely satisfy him; so he gradually accumulated a private collection made up largely of those books which were not to be found in the public library. After reading somewhat carefully a large part of the text of the Dictionnaire the writer of the present sketch is deeply impressed with the admirable manner in which the work was done. Dezeimeris evidently possessed a revenue more than sufficient to meet all his legitimate wants, and therefore he was able to devote his entire time, for a period of at least ten years, to the study of the published writings of the men whose lives and whose professional deeds he proposed to place on record. His knowledge of ancient and modern languages enabled him to get all this information from the original sources. In addition, his love of truth, the judicial type of his mind, and his strong ambition to create a book of reference that would prove of permanent value to the medical profession, fitted him in a peculiar degree wisely to select from among the hundreds of medical authors of antiquity those whose names deserved to be transmitted to posterity. It is, therefore, a particularly pleasant task to be permitted to print in this HANDBOOK even so short a tribute as the present one to an author so meritorious and at the same time so little known to Americans as is Dezeimeris. It is from this Dictionnaire, furthermore, that the present writer has derived practically all the information which forms the basis of his own sketches of the physicians and surgeons (of Europe and Asia) who flourished prior to about 1825. A. H. B.

**Diabetes, Bronzed.**—See *Diabetes Mellitus.*

**Diabetes Insipidus.**—*Synonyms:* Hyperuresis, Diuresis, Essential polyuria.

Polyuria means an excessive flow of urine. There are numerous cases in which this occurs temporarily and is due to dietetic or nervous changes, and a few in which it occurs persistently. The latter are best named *diabetes insipidus* or *essential polyuria.* I shall at the present time describe the latter cases. Instances of persistent or chronic hyperuresis were recognized and described at an early period of medical history, but no attempt was made to classify them. In 1670, however, Thomas Willis discovered the existence of sugar in the urine of some of them, and nearly a century later Sauvages described anew the excretion of sweet urine, as a distinct form of disease, under the name of diabetes anglicus. But it was not until near the end of the eighteenth century that Cullen and P. Frank placed all cases of persistent polyuria in two classes, the one having sugar in the urine and the other none, the first being called diabetes mellitus and the second diabetes insipidus. This distinction has been maintained by all subsequent observers. Diabetes mellitus is now classed with the morbid conditions of assimilation and nutrition. Therefore only the non-saccharine cases, or those of diabetes insipidus, are still thought of as essential polyurias.

ETIOLOGY.—Cases of temporary polyuria are due to a variety of conditions such as the drinking of large quantities of fluid or the eating of excessively large amounts of sugar. It is also caused by such nervous diseases as hysteria and epilepsy. Chronic polyuria has been ascribed to exposure to cold, and to a residence constantly in damp and dark rooms. However, the causative influence of these conditions has not been proved. Injuries affecting the brain and spinal cord, more especially at the base of the brain and about the sella turcica; tumors similarly located; violent mental emotions and persistent functional diseases of the nervous system are known causes in many instances. But cases are on record which can be traced to no special cause. Age evidently exerts a predisposing influence, as shown by the following statistics: Of 242 recorded cases 18 were under five years, 32 between five and ten years, 50 between ten and twenty years, 59 between twenty and thirty years, 42 between thirty and forty years, 20 between forty and fifty years, 13 between fifty and sixty years, and 8 between sixty and seventy years, which is equivalent to 75 per cent. between the ages of five and forty years. Observations in regard to sex show more than twice as many cases in the male as in the female.

It has been claimed that diabetes insipidus often is inherited. Weil[1] describes a family of 219 individuals, thirty-five of whom had diabetes insipidus. The first parents to develop the disease had children of whom 60 per cent. had diabetes insipidus; of the third generation 21.8 per cent. had the disease; of the fourth 54.1 per cent. had it; of the fifth, 28.5 per cent. had it. The disease did not materially shorten life, for one individual having it lived to be 92 and another to be 87. Such records however are uncommon and there are not a sufficient number of reliable observations on record to justify the conclusion that the disease is hereditary.

The frequency with which disease in and about the hypophysis is associated with diabetes insipidus led Frank[2] to suggest that the intermediate part of the hypophysis is a gland with an internal secretion which controls the activity of the kidneys and that excessive functioning causes polyuria. This explanation however is hypothetical.

It seems probable that either a functional or structural disease of the brain or possibly of the center in the medulla which controls the blood supply to the kidneys and excretion by them exists in all cases of diabetes insipidus.

SYMPTOMS AND CLINICAL HISTORY.—When not the result of direct injuries to the central portions of the nervous system, or of sudden mental emotions, the symptoms of diabetes insipidus generally develop slowly and without marked changes, except the gradually increasing quantity of urine which is voided and the correspondingly increased thirst.

When the urine is greatly in excess, the skin appears dry and somewhat shrunken, but much less than in diabetes mellitus. Often these patients exhibit also some paleness of the features, mental despondency, disturbed sleep, unusual weariness from moderate exercise, excessive appetite for food as well as constant thirst, and frequent eructations and flatulence, with constipation of the bowels. As much as twenty-five to fifty pints of urine may be voided daily. In most cases the specific gravity of the urine is diminished in proportion to the increase of its quantity, varying from 1.001 to 1.008. The fluid is nearly colorless. Its reaction is often neutral or feebly alkaline. Therefore it readily undergoes decomposition. Although the amount of solids in the urine is small, the propor-

* In the preparation of the first volume (A to G, inclusive) Dezeimeris had, as associates, Drs. Ollivier and Raige-Delorme; but the last three volumes were written entirely by Dezeimeris.

tion of urea is often great. A considerable thirst is felt and the mouth and lips rapidly become parched. Appetite is variable. A moderate loss of flesh is the rule, but such patients do not become emaciated. In spite of an appearance of average plumpness these patients lack endurance and ambition. When the disease is not caused by, or associated with, injuries or structural diseases of the brain or spinal cord, it may continue many years, and rarely proves fatal unless from the nature and extent of complications. Some cases have been observed to present great variations in their progress, the quantity of urine sometimes diminishing to the normal, with corresponding improvement in other symptoms, and then increasing again. In some cases exacerbations are traceable to unusual mental or nervous excitement, in others to exposure to cold and damp air, and in still others to excesses in eating and drinking.

During the active progress of essential polyuria the increased quantity of urine consists entirely of water, while the quantity of the other natural constituents voided in the twenty-four hours remains nearly the same as in health.

This explains why the waste of tissues and impairment of health is so much less in this form of disease than in diabetes mellitus, even when the actual quantity of urine discharged in the twenty-four hours is greater in the former than in the latter. The condition of the digestive organs varies much; sometimes food is imperfectly digested, causing acid and gaseous eructations, flatulency, and constipation, alternating with diarrhea. These symptoms, however, appear to depend more directly on the morbid conditions that have caused the polyuria or have existed as complications, than upon the excessive flow of urine.

Prognosis.—The duration of the disease depends almost entirely upon the nature of the causes and complications. Those cases which are associated with diseases or injuries of the cerebral and spinal centers usually either recover or prove fatal at an early period, while those which are dependent upon chronic functional disorders may continue for many years. R. Willis has left on record a case that continued for fifty years, and Neuffer one that ended fatally in four months. It is generally conceded that permanent recovery from this disease is rare, but it does occur sometimes spontaneously. Complications or intercurrent diseases cause death in much the larger number of instances.

Diagnosis.—The most reliable and characteristic symptoms of diabetes insipidus, or essential polyuria, are the persistent daily excretion of quantities of urine above the ordinary maximum of health, of low specific gravity (between 1.001 and 1.008), and destitute of sugar and albumin; unnatural thirst, increased in direct ratio to the increase in the quantity of urine voided; and a loss of endurance. At first, cases in which polyuria is caused by habitually drinking very large quantities of fluids, may be mistaken, for cases of diabetes insipidus. In the early stage chronic interstitial nephritis also may be mistaken for it. This can happen only when albumin does not occur in the urine or occurs only occasionally. In this stage of interstitial nephritis the increased flow of urine is moderate rather than excessive, and the specific gravity is almost uniformly above 1.008. A careful study of the circulatory disturbances, which are a part of interstitial nephritis and do not exist in essential polyuria, makes a diagnosis easy.

Pathological Anatomy.—Diabetes insipidus generally continues for many years, and rarely terminates fatally except through the intervention of other diseases; few opportunities, therefore, are afforded for careful postmortem examination. However, in some cases the kidneys have been found slightly enlarged, the pelvis especially distended, and more vascular than natural, but often they appeared unaltered.

Much the most numerous and important changes have been found in the brain and cord. These consist of inflammatory and degenerative changes in the region of the fourth ventricle, and less frequently in the meninges; of gummata and exostoses; and of tumors and of lesions of and about the pituitary body. Such changes within the cranium are evidently the results of prior constitutional disorders, and are in no sense dependent on the polyuria although the latter doubtless often is dependent on them. Chemical analyses of the blood have shown a moderate increase of the solid constitutents in proportion to the water. It may be safely assumed that uncomplicated polyuria does not involve uniform structural changes either in the kidneys or in other parts of the body, but rather such a modification of the renal function as to induce and maintain an increased elimination of urine.

Treatment.—In the treatment of this affection, it is of the highest importance to ascertain from the history of the patient what accidents, injuries, coincident diseases, or constitutional morbid conditions, hereditary or acquired, may have been influential in developing or perpetuating the disease. In all cases in which such causative conditions can be found, the removal when possible, or alleviation when removal cannot be accomplished, should demand careful and persistent attention.

For permanently controlling the diuresis no remedies have been found to be reliable or uniformly successful. Those who suffer from this disease should live in well-ventilated, well-lighted, warm and dry rooms; should wear warm flannel underclothes, take a warm-water bath, followed by rapid light friction with dry flannel, daily or at least two or three times a week; and take as much exercise in the open air daily as is possible without fatigue. Such quantity and quality of food may be eaten as the digestive organs of the patient will tolerate without developing gastric distress or much flatulency; but sugar should be eaten sparingly, for an excess of the latter in the blood will aggravate the polyuria. Very cold beverages should be avoided, and especially such as are diuretic, like beer, cider, and milk. Melons and grapes among fruit increase diuresis and must be eschewed.

A salt-free diet and one poor in protein have been found frequently to diminish the quantity of the urine very greatly. Minkowski[3] advises that the amount of chlorides and specific gravity of the urine of patients be determined after the ingestion of considerable salt. If both increase relatively more than the urine does he believes that the power of excreting a concentrated urine is still possessed by the kidneys. Therefore diminishing the amount of water drunk by patients will help them. But if the amount of urine increases relatively the most a salt-free diet and one poor in proteins will be a help.

Rest and sleep should be had at regular intervals and in sufficient amounts. Emotional excitement and fatigue must be avoided. To promote vicarious elimination by skin and lungs, the hot baths and friction of the skin, already advised, are important. Breathing exercise, slow climbing of hills, and a residence in a high altitude and a dry climate are useful.

Among the numerous drugs which have been employed are pilocarpine and cathartics as means of provoking elimination by other channels than the kidneys. Their utility is transitory and slight.

For their effect upon the tone of the renal blood-vessels such drugs as strychnine, ergot, and astringents have been tried. They all tend to increase blood pressure, which we would expect to aggravate, not to relieve, the important symptoms of the disease.

Although in individual cases they have seemed useful, they cannot be said to have a specific action.

Valerian, castor, musk, asafetida, camphor, belladonna, opium, and potassium bromide are other drugs which have occasionally seemed beneficial.

These drugs, however, are not to be relied upon. They may be used to meet indications in individual patients. Treatment for syphilis oftener than any other medication does good. A brain lesion of syphilitic origin causes many cases of diabetes insipidus. If a history of such infection is obtained and especially if a Wassermann is positive mercury and iodides should be used and sometimes salvarsan.

Herrick[4] has reported interesting results which he obtained in one case. A man forty-three years of age had a well-marked diabetes insipidus. He was voiding 7,500 to 11,000 c.c. of urine daily of a specific gravity of 1001. He also had symptoms which suggested a cerebral lesion or possible trouble with the hypophysis. Hoping to obtain some evidence of this by a spinal puncture, about 5 c.c. of spinal fluid was withdrawn very slowly for it was under low pressure. Soon thereafter headache, nausea, vomiting, and weakness were felt and lasted for several days. In forty-eight hours the urine diminished to 660 c.c. and did not during the next few weeks exceed 1,800 c.c. Its specific gravity varied from 1005 to 1031. For a month the patient apparently made a recovery but slowly thereafter the old symptoms began to return but not as persistently or severely as before.

The experiments of Farini,[5] of Venice, demonstrate that the extract of the posterior lobe of the pituitary body will, sometimes at least, reduce the elimination of urine to near the normal point and mitigate all other symptoms proportionately. His first case was a young woman upon whom he had tried many lines of treatment without success. Among other things he tried adrenalin, ovarian, pancreatic, and thyroid extracts without avail. But injections of the pituitary body were followed by a sudden diminution of the excretion to normal and disappearance of thirst. However, when this treatment was discontinued the polyuria promptly reappeared.

His second case, a woman of forty-two, had not obtained relief by any treatment until the injection of the pituitary was begun when the excretion of urine fell from a daily quantity of 7,000 to 8,000 c.c. to an average of 2,000 c.c.

These results are surprising because the physiological action of pituitary substance upon the kidney is to increase the excretion of urine.

From this brief review of the treatment of diabetes insipidus it is evident that there is not a specific for it, but that syphilitic treatment helps some cases, a salt-free and restricted protein diet helps a proportion of cases, and Farini's results show that relief also can be obtained in some cases by injections of the extract of the pituitary body.

N S. Davis, Jr.

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**Diabetes Mellitus.**—Definition.—Diabetes mellitus is a disease characterized by the constant output of glucose in the urine on a normal carbohydrate intake. Neither the absence of a glycosuria on a restricted carbohydrate regimen, nor its presence with a large intake of sugar, especially of grape sugar, is of significance in establishing a diagnosis. The glycosuria of diabetes mellitus persists throughout months and years. The presence of glucose in a single specimen of urine may be due to a variety of causes that have no connection with the disease diabetes mellitus.

Pathological Physiology.—The normal human circulating blood contains approximately 0.1 per cent. of glucose. As long as the glucose does not rise above this concentration it will not pass through the kidneys into the urine. However, if the percentage is increased, that is, if there is a hyperglycemia, the kidneys are no longer impermeable to the accumulated glucose, a glycosuria results and persists until the blood sugar returns to its normal percentage or below it. This is the direct cause of the glycosuria in diabetes mellitus.

Cases have been cited which apparently prove the existence of a *renal diabetes*, that is, the constant presence of a glycosuria in persons with a normal percentage of sugar in the blood. The cause of the glycosuria in these instances lies in the kidneys, which allow the passage of sugar, although there is no hyperglycemia. Such cases, however, are very rare and it is extremely difficult to establish a diagnosis, which must be based on a careful blood-sugar determination. That such cases probably do exist is borne out by the fact that the drug phlorizin causes a glycosuria which persists so long as any sugar whatever remains in the blood. Thus the kidney may under certain conditions give rise to a glycosuria through its inability to retain the normal 0.1 per cent. of glucose in the blood. This sugar-regulating mechanism may be regarded as a definite function of the kidney, which like other functions, may be increased or diminished by pathological conditions. While in the above examples there is evidence of the diminished function, the opposite condition may occur in the febrile infectious diseases (pneumonia, typhoid fever, etc.) and in chronic interstitial nephritis, where a considerable hyperglycemia may be found without the occurrence of a glycosuria. For this reason the glycosuria of diabetes mellitus may partially or even completely disappear when such a nephritis develops.

Since in the great majority of cases of diabetes mellitus there is a hyperglycemia, the question presents itself, what is the origin of this excess of sugar in the blood? Carbohydrates, in whatever form they may be ingested, are usually absorbed from the intestine as glucose. This glucose passes through the tributaries of the portal vein to the liver to be stored there. Glucose is a monosaccharide, represented by the formula $C_6H_{12}O_6$. The form in which it is stored in the liver is known as glycogen, which may be designated as $(C_6H_{10}O_5)_x$, that is to say, as consisting of many molecules of glucose. Glycogen is sometimes spoken of as animal starch in contradistinction to plant starch which has a similar formula and is synthesized by plants from an unknown number of molecules of monosaccharides. Glucose is likewise stored in the muscles in the form of glycogen. The liver may contain as much as fourteen per cent. of glycogen, the muscles as high as three per cent.

In the liver and muscles the glycogen is again converted into glucose by a diastatic ferment and is given up to the body tissues according to their need. In the normal organism this production of glucose from glycogen proceeds just rapidly enough to maintain the glucose of the blood at or near the concentration of 0.1 per cent. If the function of these storehouses fails—and here the liver must more particularly be considered—a hyperglycemia may occur, resulting in glycosuria and diabetes mellitus. There are two possible ways in which the liver may be responsible for a hyperglycemia: (1) Through the inability to convert into glycogen the glucose brought from the intestine, and to store this; (2) through an overproduction of glucose from glycogen—in other words, through the too rapid mobilization of glucose.

The first of these possibilities need never be con-

sidered as a cause of diabetes mellitus. The inability of the liver to convert into glycogen the glucose brought from the intestine, presents itself as a factor in clinical medicine only in the production of the so-called *alimentary glycosuria.*

In a given time the liver can convert a certain amount of glucose into glycogen, and no more than this amount. Any glucose coming through the portal system above this amount cannot be assimilated and must pass through the hepatic into the general circulation, thus giving rise to a hyperglycemia. The ordinary plant starch of the food is broken down into its monosaccharide constituents so slowly that only a moderate quantity of glucose is absorbed by the intestine at any time and this the normal liver can assimilate very readily. However, when glucose or other mono- or disaccharides are eaten, a different condition ensues in the intestinal canal, inasmuch as these simpler carbohydrates need little or no digestion before absorption by the intestine. The result is that the whole amount of glucose passes to the liver at one time and cannot be taken care of by that gland. The glucose which the liver cannot convert into glycogen passes into the general circulation and produces hyperglycemia and glycosuria. The glucose in the urine persists until the amount of sugar in the blood returns to normal. For each variety of carbohydrate the body has a certain limit of tolerance which cannot be exceeded without a resulting glycosuria. There are slight variations in these amounts for different individuals but in general the upper limits of assimilation are as follows:[1]

| | | |
|---|---|---|
| Lactose | 120 | grams |
| Saccharose | 150–200 | grams |
| Levulose | 120–150 | grams |
| Glucose | 150–180 | grams |
| Galactose | 20 | grams |

(It is to be noted that the resulting sugar in the urine may be of the same form as the excess of carbohydrate ingested.)

Such a glycosuria, due to the excessive intake of some form of carbohydrate, is spoken of as an alimentary glycosuria. It is a purely physiological phenomenon of a transitory nature and must be sharply distinguished from diabetes mellitus.

Von Noorden,[2] basing his reasoning on the evidence afforded by the experiments of his pupils and others, claims that the hyperglycemia in diabetes mellitus is caused by an overproduction of glucose from glycogen in the liver. This is usually spoken of as the *increased mobilization of glucose by the liver.* This is not the result of any disease on the part of the liver, but is brought about by changes in the regulating mechanism which controls the glucose output of that organ. The formation of glucose from glycogen may be influenced in two directions by the body, that is to say, there are certain factors that tend to check it and others that accelerate it. Of the former, the *pancreas* is by far the most important. After extirpation or destruction of the pancreas in animals a rapidly fatal condition resembling diabetes mellitus follows. If the duct of the pancreas is tied, or if the gland is transplanted, or if it is incompletely extirpated so that more than one-tenth of it remains intact, no change in the animal's condition ensues Therefore it is believed that the carbohydrate metabolism is normally controlled by a so-called internal secretion of the pancreas. The body deprived of its presence suffers from diabetes mellitus. It is probable that the islands of Langerhans are the part of the pancreas that produces this internal secretion. Normally, the secretion limits the amount of sugar formed from glycogen by the liver. As soon as its restraining influence is removed, the liver mobilizes all its glycogen as glucose and persistent hyperglycemia and diabetes mellitus are the result.

The internal secretion of the *thyroid gland* in its turn tends to check this function of the pancreas. An excess of thyroid secretion, as in exophthalmic goiter, therefore results in hyperglycemia and a diminished sugar tolerance, while the opposite condition, as in myxedema, brings about an increased sugar tolerance. The *parathyroids,* on the other hand, produce by their internal secretions diametrically opposite results to those of the thyroid.

The secretion of the *suprarenal glands* accelerates the formation of glucose from glycogen by the liver. A subcutaneous or intravenous injection of suprarenal extract will cause hyperglycemia and glycosuria. Our knowledge of the part that the adrenal gland plays in diabetes mellitus is so far based on circumstantial evidence only, since no method up to the present time has demonstrated an excess of suprarenal secretion in the blood or tissues in any disease. As negative proof may be taken the fact that in Addison's disease, in which the epinephrin is diminished, there is an increased tolerance of carbohydrates. Furthermore, there are impulses proceeding from the central nervous system which stimulate the suprarenal glands to greater activity in this direction. The piqûre of Claude Bernard (the puncture of the brain in the floor of the fourth ventricle) is the best known experiment exemplifying this influence. The stimuli produced thereby proceed through the left sympathetic nerve to the left suprarenal gland, whose secretion, conveyed by the blood stream to the liver, there exerts its sugar mobilizing effect. An interruption of any part of this circuit robs the procedure of piqûre of any effect on the carbohydrate metabolism.

The *hypophysis,* especially through its posterior lobe, according to Cushing[3] and his coworkers, liberates a chemical substance which causes glycogenolysis and glycosuria. Thus cases of acromegaly exhibit a diminished tolerance for sugars.

The increased mobilization of sugar plays a part in the production of chronic glycosurias though it is not the only etiological factor involved, as von Noorden claims. This has been forcibly pointed out by Minkowski.[4] For many years it has been assumed that one of the causes of the hyperglycemia of diabetes lies in the diminished power of the body tissues to oxidize glucose. The proof of this assumption is contained in the following questions and answers:

1. How does acidosis occur if sugar is burned within the organism? (Acidosis does occur in the severe types of diabetes mellitus and yet it is known that if about fifty grams of carbohydrate are oxidized during twenty-four hours acidosis is prevented.)

2. Why does glycosuria occur in diabetics during starvation? (In advanced cases glycosuria is present during starvation, which indicates that at such a time the body is incapable of oxidizing even a minimal quantity of carbohydrates.)

Recently, Kowlton and Starling,[5] and Maclean and Smedley[6] have shown that the heart of the depancreatized dog did not consume sugar on perfusion. On adding pancreatic extract to the perfused solution the glucose was oxidized. This would seem to indicate that the internal secretion of the pancreas is indispensable for the oxidation of glucose by the body tissues.

There are, therefore, as far as our present knowledge permits us to speak, two elements concerned in the production of hyperglycemia and glycosuria in diabetes mellitus. Of these the first appears to be the more important in influencing the course of the disease: (1) Diminished power of the body tissues to utilize glucose. (2) Increased mobilization of glucose by the liver.

Etiology.—No age is exempt from diabetes mellitus. It rarely occurs in infancy; it becomes more frequent with advancing years and is most often found in the

sixth and first half of the seventh decade of life. The preponderance of cases is in the male sex. A relatively large percentage occurs among the richer classes. This has been variously attributed to the more luxurious diet and greater nervous strain. The Jewish race, more than any other, is subject to the disease. Frequently brothers and sisters are affected.[7] In many instances diabetes mellitus is transmitted from parents to children and then has a tendency to appear at a younger age in each successive generation. In the past it was believed that the disease might be an infectious one. This theory has not stood the test of more critical investigation. Stout persons are particularly subject to diabetes mellitus. With such patients the illness is usually of a benign nature when it develops with advanced years, though in younger individuals it may run a rapidly fatal course.

Any change in the pancreas which involves the greater part of the gland, especially if the islands of Langerhans are included, results in diabetes mellitus of the severest type. Carcinoma, chronic interstitial pancreatitis, sclerosis of the pancreatic arteries, obstruction of the pancreatic duct by calculi followed by glandular atrophy and any lesion which results in destruction or degeneration of pancreatic tissue, may be the etiological agent. Pathologists have attempted to demostrate pancreatic involvement in every case of diabetes mellitus whether of mild or severe type, but the effort has not been entirely successful. However, the number of negative cases is constantly diminishing and this is probably due to the increasing skill of the men who have specialized in this study, and also to the recognition of the fact that the islands of Langerhans are the portion of the gland which is responsible for the pancreatic control of carbohydrate metabolism.[8, 9, 10] Moreover, it must be borne in mind that even a gland which is normal under the microscope may not have exhibited a normal function during life.

The important part which the liver plays in the control of carbohydrate metabolism points to that organ as one of the possible factors in the causation of this disease. Thus far all attempts to associate changes in the liver with diabetes mellitus have failed. In only one condition, *diabète bronzè*, in which there is cirrhosis of the liver followed by skin pigmentation, and sclerosis of the pancreas, is there any possible relationship proved and in this instance the pancreatic lesion appears to be responsible for the glycosuria.

Whenever the thyroid gland is overactive there is a diminished tolerance for carbohydrates. This may be readily demonstrated in exophthalmic goiter. Some of these cases actually develop a true diabetes mellitus. As has been previously shown, the hypophysis plays a somewhat similar rôle in regard to carbohydrate metabolism as does the thyroid gland. It is therefore evident why cases of acromegaly show a low limit of tolerance for sugars and are frequently complicated by diabetes mellitus.

Any severe nervous shock, whether of purely psychical nature, such as fright, anxiety, or grief, or of a physical kind, especially trauma about the head, frequently results in a temporary glycosuria and occasionally in diabetes mellitus. It is difficult in any given case to associate the cause with the result, as proof of a normal, sugar-free urine antedating the injury may be lacking, and the characteristic symptoms of the disease may not develop until some time after the accident. Even in the absence of these criteria it becomes necessary to bear this etiological factor in mind, especially in medicolegal cases. The changes in the carbohydrate metabolism of these patients may possibly be similar to that previously detailed under piqûre.

In most cases of diabetes mellitus a definite etiological factor cannot be determined during the lifetime of the patient.

Clinical Course.—The onset of diabetes mellitus usually causes no disturbance and is consequently not noted. Only when the glycosuria has persisted for some time and other symptoms make the patient anxious is the disease as a rule diagnosed. This is frequently seen in life insurance examinations, where glycosuria which later develops into diabetes mellitus, is not a rare accidental finding. In those isolated instances where frequent urinary examinations have been made throughout the life of a diabetic, it has been found that the demonstration of a glycosuria preceded all other indications of the malady, by months at least, and in some cases by years.

The first clinical manifestations are usually pruritus (especially pruritus vulvæ), increased appetite, great thirst, polyuria, furunculosis, loss of weight, weakness, or neuralgic pains in various parts of the body. Almost any one of the symptoms and complications to be detailed later on, may become the initial complaint in this disease. Often such discomforts do not suggest diabetes mellitus to the physician and yet it is in this early stage that a diagnosis is especially important because the earlier a case is treated, the better is the prognosis. It is an easy matter to obtain an adequate specimen of urine and test it for sugar, thus verifying or setting aside any suspicion that we may have before us a case of diabetes mellitus. On the other hand, it is impossible to estimate the significance of every transitory glycosuria which may be discovered. Many of these subsequently develop into a true diabetes mellitus, while in other cases of this kind the urine never again shows the presence of sugar. It is the duty of the physician to examine the urine of such patients frequently and where the disease does develop, to treat it rigorously from the beginning.

The progress of the disease varies greatly. Occasional authentic cases have been reported that, even though of severe type, have been cured. However, these instances are so few that they deserve no further consideration here. As a rule the glycosuria becomes gradually more marked, polyuria, thirst, loss of weight, and weakness advance steadily. The acid bodies appear in the urine and the patient dies in coma as the result of the so-called acidosis. The rapidity with which the disease progresses depends upon many factors, of which the age of the patient seems to be the most important. In general, the younger the patient the quicker is the succession of events. According to von Noorden's extensive experience the approximate duration of the disease for various ages is: first to tenth year, 2 years, tenth to twentieth year, 4 years, twentieth to thirtieth year, 6 years, thirtieth to fortieth year, 10 to 15 years, after the fortieth year severe cases are the exception and under proper treatment the disease is generally very mild. In older people the termination of the disease is not so frequently in coma, various complications playing a comparatively important rôle. The circulatory disturbances, arteriosclerosis and its complications, cerebral apoplexy, gangrene of the extremities, etc., pulmonary tuberculosis and various forms of skin infection and sepsis are most often met with.

Symptoms.—The urine usually shows a high specific gravity, a light color, an acid reaction, a positive reaction for glucose and an increased volume. Emphasis must be laid upon the fact that a urine may appear normal in every way and still be that of a diabetic and contain glucose. The careless practice of not examining a urine for sugar because its specific gravity is approximately 1020 or its color dark, cannot be too strongly condemned.

The *specific gravity* is usually 1030 or higher. It is not rare, however, to find much lower figures, especially in cases of chronic interstitial nephritis, of which the following are examples:

| Urine volume c.c., in 24 hours | Glucose, per cent. | Specific gravity. |
|---|---|---|
| 1,440 | 2.0 | 1,022 |
| 4,560 | 1.3 | 1,018 |
| 4,320 | 1.7 | 1,015 |
| 4,300 | 1 0 | 1,013 |
| 3,360 | 0.5 | 1,009 |

The presence or absence of a *glycosuria* must be carefully determined. Many substances, such as glycuronic acid and other sugars beside glucose, such as pentose or lactose, may be present to give a positive reaction with the usual Fehling's test. The preliminary qualitative determination must be made on a twenty-four hour specimen of urine with all possible care. A positive phenylhydrazine test, fermentation with yeast, and dextrorotation in the polariscope should be obtained before the substance which reduces Fehling's solution is regarded as glucose. A twenty-four-hour specimen is absolutely necessary since the urine in the morning is apt to be free from sugar, whereas that passed later in the day, after food ingestion, may contain it in considerable amounts. When a glycosuria has been confirmed, it becomes necessary to establish whether it is of a transitory nature or that of true diabetes mellitus. If the diet is a normal one, containing a liberal amount of starch and no excess of the various forms of sugar, we may consider the glycosuria as dependent upon diabetes. The patient's tolerance for starches should be determined according to the principles set down under treatment. If the amount of sugar is very small and diminished or absent on second examination, and if the correction of any gross error in diet such as of excessive candy (glucose) or cane sugar, is followed by a disappearance of the glycosuria, a negative diagnosis of diabetes mellitus is warranted. There remain a certain number of cases, however, in which some doubt must exist and it may become necessary to determine their sugar tolerance by the so-called *glucose test.* This is done by giving 100 grams of glucose before breakfast (*i.e.* on an empty stomach), and examining the urine for twenty-four hours thereafter. The glucose is most readily taken dissolved in black coffee. A normal person will show no glycosuria, except possible traces during the first six hours; even a small amount of glucose in the urine must be considered as indicating a diabetic tendency. All questionable cases should be controlled by urinary examinations over periods of months and even of years.

The severity of any case of diabetes mellitus is measured by the glycosuria. If the sugar disappears from the urine after removing all the carbohydrate from the food (see standard strict diet, below) the patient may be considered as suffering from a mild type of the disease; on the other hand, if it persists, the illness is classified as severe. These grades of intensity pass into one another without sharp demarcation. The severe form of the disease is sometimes further subdivided. The urinary sugar excreted by diabetics is dependent in amount primarily upon the carbohydrates of the food. As a secondary source, the proteins must be considered. In a few cases which do not become sugar free when deprived of carbohydrate food, this may be accomplished when the protein diet is cut down. This type of the disease stands midway in severity between that in which the glycosuria disappears on the carbohydrate-free diet, and that in which the glycosuria persists even on a diet with restricted protein. Recent investigations have gone far to show that a third though small source of glycosuria must be sought in the fats. (Ringer.[11])

Using nitrogen in the urine as an indicator of the quantity of protein digested in the body, a ratio between it and the glycosuria, the so-called D:N ratio, may be established. When the diet is carbohydrate-free, this is capable of giving some very valuable information as to the amount of glucose derived from protein. The D:N ratio has been demonstrated to rise occasionally as high as 5:1 (Falta[12]) which probably indicates the maximum amount of dextrose that can be derived from protein. The very advanced stage of the disease which this proportion indicates may be seen from the fact that 3.65:1 has been called the "fatal ratio" (Mandel and Lusk[13]).

The total quantity of sugar found in the urine varies very greatly, amounts up to 300 grams being not uncommon. Occasionally as much as one kilo may be excreted in twenty-four hours. Neither the percentage nor the total quantity of grape sugar in the urine is of very great importance in judging the severity of any case. In every instance the carbohydrate intake and the output must be balanced against one another. A patient excreting 100 grams of glucose with an intake of 120 grams of starch is considered as having a plus balance of 20 grams, that is to say, he is burning 20 grams of the ingested carbohydrate. On the other hand, if the glycosuria shows 100 grams and the carbohydrate intake is only 80, the patient has a balance of minus 20; twenty grams of glucose must be derived from protein or fatty food. These two cases, though both excreting the same quantity of glucose, 100 grams, differ widely. The first is of the mild type, the second severe. Therefore, it is important to know not only the total quantity of urinary glucose but also the carbohydrate intake and to determine the balance between the two.

The *quantity of urine* varies very greatly. In many cases, even though a considerable degree of glycosuria exists, there is no increase in the amount of urine. The following is an instance of this kind:

Within two weeks, C. K., aged fifty-nine, a patient suffering with the mild type of diabetes mellitus, which subsequently became severe, passed twenty-four-hour amounts of urine of 650, 740, and 860 c.c., containing respectively 3.9, 1.1, and 1.0 per cent. of glucose.

As a rule, however, polyuria and glycosuria exist together, the excretion of sugar demanding an increased amount of fluid. Two to four liters are commonly passed; amounts up to ten liters are met with at times, especially in advanced, untreated cases, larger volumes of urine have been noted, but are the exception. The intensity of the glycosuria tends to increase more rapidly than does the polyuria. This may be seen from the data of one patient at progressive stages of the disease:

| Volume of urine. | Glucose. | |
|---|---|---|
| 1,860 c.c. | 1.4 per cent. | 25.8 grams. |
| 2,950 c.c. | 2.8 per cent. | 82.6 grams. |
| 4,760 c.c. | 3.9 per cent. | 185.6 grams. |
| 6,150 c.c. | 3.7 per cent. | 258.3 grams |
| 9,000 c.c. | 5.0 per cent. | 450.0 grams. |

Marked polyuria, since it necessitates frequent voiding, is very likely to result in restless nights and uneasy days, and its diminution, when the glycosuria is partially or completely set aside by proper diet, is often a very great relief.

*Polydipsia* and a *dry skin* are the direct results of polyuria. Thirst is frequently so intense as to become a cause of suffering to the patient. It is generally increased when bicarbonate of sodium is administered. The same measures that diminish polyuria also relieve the thirst.

*Polyphagia* is a symptom present in nearly every case in which there is a considerable excretion of sugar. The reason is obvious: the loss to the system of unburned carbohydrate must be compensated for. When, as frequently happens, the indiscriminating appetite of the patient leads him to consume carbohydrate food which only increases the glycosuria without satisfying the body's needs, the polyphagia may reach enormous proportions.

It is now generally acknowledged that the actual calory requirement of diabetics, at least of all but the very severe cases, is the same as that of normal individuals. The diet of these patients should therefore contain sufficient calories to maintain the nutrition plus the caloric value of the urinary glucose. In mild cases this may readily be accomplished if the urine is rendered sugar free. All the food is then utilized by the body and the abnormal appetite disappears, its cause having been set aside. In the severest cases, however, a different problem confronts us. Here the glycosuria may arise not only from the ingested carbohydrate but also form protein and possibly from fat. Furthermore, the acid substances, of which β-oxybutyric acid is the most complex, appear in the urine. These substances are derived chiefly from the fats and in part from the proteins. All these abnormal urinary constituents represent a loss of unburned material, of unused calories, to the diabetic. Reducing the possible losses to figures, we get the following results:

| Food substances. | Caloric value of 100 grams. | Maximum amount to be derived from 100 grams and found in the urine as: | | Caloric loss in 100 grams. |
|---|---|---|---|---|
| | | Glucose | β-oxybutyric acid | |
| Carbohydrates..... | 410 | 100 | 0 | 410 |
| Proteins | 410 | 80 | 30-40 | 410 |
| Fats | 930 | probably some | 36 | 162 |

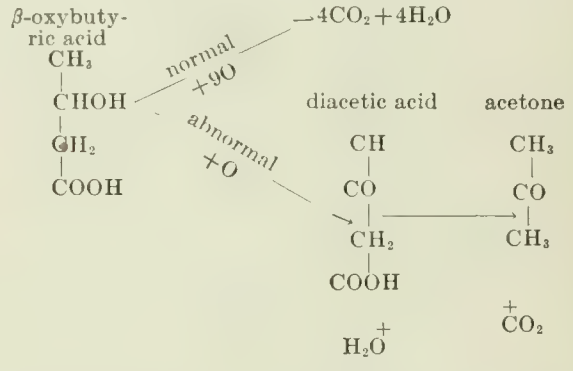
(The above table represents a condition toward which the diabetic may be regarded as progressing as his disease becomes more severe, but which he will never reach. There is in all probability at least some oxidation of carbohydrate material in every instance and obviously the amount of urinary glucose and β-oxybutyric acid given cannot be derived from 100 grams of protein at the same time.)

The excretion of glucose and β-oxybutyric acid in the urine in quantities sufficient to account for nearly the whole amount of proteins and carbohydrates of the food and a portion of the fats, readily explains the loss of weight and emaciation found, in spite of good appetite, in the advanced cases. It is this degree of perversion of the metabolism that becomes a menace to the life of the diabetic, and it is the object of treatment to forestall it. The loss of weight in some of these cases is scarcely credible. Naunyn records instances of individuals of average build and height, reaching a weight of 30.5, 31.0, 35.5, 36.6 and 39.5 kilos (about 67 to 87 pounds) in the course of the disease. These were all untreated cases of diabetes. Such emaciation is naturally accompanied by considerable lassitude and weakness.

When the human organism oxidizes less than fifty to seventy grams of carbohydrate material during twenty-four hours, there appear in the urine the so-called acid bodies. These bring about certain changes within the organism which are known as *acidosis*. This is true whether the lack of starchy food is due to external causes, as on a meat-fat diet, in starvation or marked vomiting, or from anomalies of metabolism within the body, as in severe cases of diabetes mellitus, in which all ingested carbohydrate food is excreted as glucose in the urine. The acid bodies are:

β-oxybutyric acid, $CH_3CHOHCH_2COOH$.
Diacetic acid, $CH_3COCH_2COOH$.
Acetone, $CH_3COCH_3$.

In the course of normal metabolism a portion of the food fat is changed to fatty acids and a part of the proteins to amino acids. These products represent only an intermediate step; they are finally excreted as urea, ammonia, carbon dioxide, and water. Many of them, as they are broken up into less complex members of their series, are at one time represented by β-oxybutyric acid, which is further oxidized to carbon dioxide and water. It is a curious and unexplained fact that this breaking up of β-oxybutyric acid into water and carbon dioxide can take place only while carbohydrates are being oxidized within the body. The β-oxybutyric acid is said to "burn as the fire of the carbohydrates." In the absence of the proper metabolism of starch and its derivatives, acetone and diacetic acid are formed from β-oxybutyric acid instead of water and carbon dioxide. These steps may be represented by the following formulæ:




It is thus seen that the fats and to a lesser extent the proteins are the source from which the acid bodies excreted in the urine are derived. The first of the acid bodies to be present in the urine is acetone. As the utilization of carbohydrates by the diabetic diminishes, β-oxybutyric acid is less completely changed and the more complex substances, diacetic acid and β-oxybutyric acid rapidly appear. Hence if β-oxybutyric acid is found in the urine it may safely be assumed that acetone and diacetic acid are present; the converse is, however, not true.

Another path of excretion of acetone is through the lungs. This substance has been assumed to be the cause of the "fruity" odor of the breath of diabetics. This symptom is, however, rarely found and is of doubtful value.

(The above statements are strictly true from a clinical point of view, though it must be recognized that acetone is probably formed from diacetic acid only at the physiological exterior in the body, in the pulmonary alveoli and in the urine after leaving the kidneys.[14])

The acids necessarily combine with the alkalis of the blood and tissues after the small amount of fixed alkali has been made use of. The most readily available is ammonia. In a normal human urine about 0.5 gram of this is daily excreted. The remainder of this substance is found in combination in the urine as urea. The acid bodies combine with this ammonia, which ordinarily goes to form urea and the uri-

nary ammonia is consequently found to increase. Magnus Levy presents the following figures to show how these substances parallel one another:

0.5–1.0 gram $NH_3$ in 24 hours is normal.
2 grams $NH_3$ in 24 hours indicate approximately 6 grams $\beta$-oxybutyric acid.
5 grams $NH_3$ in 24 hours indicate approximately 20 grams $\beta$-oxybutyric acid
8 grams $NH_3$ in 24 hours indicate approximately 36–40 grams $\beta$-oxybutyric acid.

If alkalis are given under these circumstances, the ammonia may diminish in amount and the above ratios no longer hold good. Practically every patient having an acidosis of any severity is placed upon an alkali therapy. Therefore many dispute the value of an ammonia determination. However, the ammonia determination in these cases is even more important than the tedious and difficult estimation of the acid bodies. It shows to what extent the available alkali of the body is being drawn upon and how close is the danger of acid intoxication and fatal coma.

Four to six grams of urinary ammonia may be excreted in very severe cases for periods covering weeks and months. Amounts exceeding ten grams have been recorded but are the exception even in the stages immediately preceding the onset of coma.

The maximum amount of acid bodies, computed as $\beta$-oxybutyric acid, daily excreted without the aid of medication, is approximately thirty grams. If the production exceeds the output, the excess remains in the body until it can combine with some base, for only in such a combination can the acids pass out in the urine. Thus the reason why alkalis may increase the output of $\beta$-oxybutyric acid becomes clear. Magnus-Levy and Joslin have both demonstrated cases where the excretion of acid substances was approximately 150 grams of $\beta$-oxybutyric acid when large amounts of bi-carbonate of soda were given. Under such circumstances the diabetic is in constant danger from the deleterious effects of these substances. The intoxication usually terminating in coma and death is the result of the retention of the acid bodies. Whether they act by poisoning the tissues or by withdrawing from them vitally necessary alkali is a matter of dispute.

Diabetic coma never occurs in any one whose urine has not previously shown marked amounts of $\beta$-oxybutyric acid constantly present for some time. The onset may occur suddenly as the result of a great physical effort or mental strain. Usually the symptoms develop more slowly. Any condition which puts increased demands upon the diabetic patient may be looked upon as a predisposing cause of coma; among these are septic infections, the administration of anesthetics, gangrene, or any of the severer complications of the disease. Gastric and intestinal disturbances, irritability alternating with periods of fatigue and lassitude, may persist for several days or weeks until drowsiness becomes more marked and gradually deepens into coma. The patients at this time lie quietly and breathe very deeply in a characteristic manner, while maintaining the normal respiratory rhythm. Death usually follows within twelve to twenty-four hours after drowsiness has become marked.

Complications.—These are very numerous. There is hardly a case of severe diabetes that does not exhibit one or more of them at some time. The occurrence of any one of them even in an apparently healthy person, suggests the possibility of diabetes as an underlying cause.

1. *Skin.*—Itching of the skin, especially pruritus vulvæ, is very common. Furunculosis, carbuncle, and eczema are frequently found. Gangrene, usually of the lower extremities, is often associated with arteriosclerosis In some cases of diabetes, cirrhosis of the liver and pancreas is accompanied by brown or slaty pigmentation of the skin. The symptom complex is known as *diabète bronzé*. The pigmentation is caused by two distinct elements, an iron-containing one, hemosiderin, and one which does not contain iron, hemofuscin. The origin of these substances is at present purely a matter of speculation. In the present condition, also spoken of as hemochromatosis, the pigments are found in practically every tissue of the body.

2. *Respiratory System.*—Pulmonary tuberculosis is often present. Naunyn demonstrated it in 12.6 per cent. of 262 living patients. In cases seen in and about New York City it is less prevalent. Gangrene is not an infrequent cause of death. It may be acute, following a pneumonia, or may occur in a subacute or chronic form, especially in older people. The sputum and breath may not have the foul odor usually associated with gangrene of the lungs. Acute pneumonia occurs frequently and offers a very bad prognosis.

3. *Cardiovascular System.*—Arteriosclerosis very often develops and may become of extreme importance. Apoplexy, gangrene of the lower extremities preceded by intermittent claudication, nephritis, angina pectoris are among the sequelæ. Cardiac weakness due to the atrophy of the myocardium is not infrequent.

4. *Edema.*—Accompanying nephritis and cardiac weakness are often responsible for edema occurring during the course of the disease. Enormous accumulations of fluid are frequently brought about by various therapeutic measures. Bicarbonate of soda administered in large amounts may produce edema especially when there is an impairment of kidney function. It probably causes water retention in an exactly similar manner as excess of sodium chloride does in the well-known type of case decribed by Widal and by Strauss. The green day and the oatmeal day diet have a marked tendency to be followed by edema. This may be great enough to produce a gain of weight of several pounds. This increase of weight as well as the edema promptly disappear when the strict diet is resumed. The appearance of this edema may be forestalled by the exhibition of diuretic doses of theocin. This drug should be employed only in those cases that are known to develop edema. The cause of this edema is probably a toxic action brought about by these diets upon the smaller blood-vessels.

5. *Digestive System.*—Pyorrhea alveolaris or looseness of the teeth may point to diabetes. Considering the quality and quantitiy of the food it is scarcely remarkable that nausea, vomiting, "heartburn," and diarrhea occur. These symptoms should always be looked into as they may be forerunners of diabetic coma. Constipation, because of the withdrawal of water from the intestine by the polyuria, is often troublesome. Through occlusion of the pancreatic ducts by calculi, tumors, or other causes, both the internal and external secretions of the pancreas may become deficient. In these cases the stools become very voluminous, contain considerable amounts of neutral fat and much undigested muscle fiber, give a negative reaction for trypsin, and have a very foul odor.

6. *The Nervous System.*—Peripheral neuritis is one of the most common and troublesome of the complications. Numbing, tingling, anesthesia, neuralgic pains, muscular cramps, and paralysis may be found. The lower extremities are most often involved but any of the peripheral nerves, including those of the cranial system, may be affected.

Symptoms resembling those of tabes are not unusual: loss of knee jerks, perforating ulcers of the foot with diminished sensation or anesthesia of the lower extremities, occur frequently. Bladder and rectal disturbances cannot be counted among the complications of diabetes mellitus. The reaction of the pupil to light, if impaired, is diminished and not absent.

The lesion of the nervous system responsible for these changes has not been definitely determined. In some cases degeneration of the posterior columns of the cord have been demonstrated, while in others only the peripheral nerves show pathological changes.

7. *Eyes.*—Retinitis resembling that found in nephritis may occur. Cataract often comes on in the course of the disease. Paralysis of the extrinsic eye muscles and atrophy of the optic nerves are occasionally found.

TREATMENT.—The *principles* on which the treatment of diabetes mellitus is based are two-fold: (1) The increase of the body's ability to utilize glucose; (2) the prevention of acidosis.

Experience has shown conclusively that if the diabetic's carbohydrate food is kept below the minimum that will induce glycosuria, the power to utilize glucose will gradually increase. If the intake of starchy food is not suitably restricted, the progress of the disease is usually very rapid.

Acidosis is kept in check by limiting the formation of the acid bodies. This in practice is accomplished in only one way: by increasing the carbohydrate tolerance of the patient. (See discussion in previous section of this article.) Thus, the principle of treatment outlined in the preceding paragraph is productive of a direct result, the increase of carbohydrate tolerance, which in its turn prevents the formation of the acetone substances. In advanced cases with marked acetonuria some starches must be allowed, at the risk of increasing glycosuria, since even a fractional utilization of ingested carbohydrate becomes necessary to prevent coma. When the disease has advanced to such a stage that the formation of acid bodies can no longer be controlled, alkalis must be resorted to to aid their elimination.

*Equipment Necessary.*—Any physician attempting to manage cases of diabetes mellitus should have at his command certain laboratory facilities. The measurement of the volume of urine, determination of the reaction to litmus paper, and the specific gravity are easily carried out. Facilities for doing Fehling's, as well as the fermentation and phenylhydrazin tests, should be at hand to substantiate the presence or absence of glycosuria. To ascertain the percentage of sugar the polariscope may be used (if beta-oxybutyric acid be present, a reading of the urine must be made before as well as after fermentation, as this substance is levorotatory, while glucose is dextrorotatory), or one of the titration methods may be employed.*

Of the many qualitative tests for the acid bodies only a few simple ones are essential. Legal's test for acetone and Gerhardt's ferric chloride test for diacetic acid are excellent. With a little practice it is possible to gain an approximate estimation of the acidosis by the intensity of the color yielded by these procedures. The degree of reaction may be charted by a series of + signs ranging from + up to ++++, thus giving a guide as to the progress of events. In marked cases of acidosis, the determination of the ammonia and total nitrogen is extremely desirable. The quantitative test for the acid bodies is very cumbersome and yields no clinical data which cannot be derived from the examinations already mentioned. Office scales are obligatory. The weight of the patient is one of the best criteria of his progress. To a large extent the quantity of food to be eaten may be regulated by it. Food balances† enable the physician to determine for himself the weight of slices of bread, oranges, etc., and thus give him a clearer understanding of what he is ordering. Familiarity with such an instrument is of great help when it becomes necessary to direct patients in its use. Diet tables* should be acquired in order to adjust the calories, protein, fat, and starch intake intelligently. The use of these figures is not very easy to master and yet without them the best results cannot be obtained.

*Drugs.*—It is very tempting to look to some means of medication as a cure for diabetes. Urotropin, arsenic, belladonna, and many other drugs have been suggested, tried, and even advocated, and yet to-day it is certain that we have no drugs to supplant the dietetic treatment. The patent medicines often looked upon as advantageous usually entail dietary restrictions which are in reality the cause for the improvement which may follow. Salicylic acid and its derivatives and the opium preparations will at times diminish glycosuria. Their use should be restricted to the treatment of special cases and should not be an indiscriminate routine procedure. In general, drugs should be prescribed for diabetics to meet definite symptoms much as they are for other patients. Care should be exercised that prescriptions do not contain any of the sugars. The only drug used in a routine way is bicarbonate of sodium in acidosis.

*Exercise and Hygiene.*—In the milder type of cases moderate exercise is usually of aid in increasing the combustion of glucose. The amount and kind of exercise must be determined individually in every instance. If it diminishes the glycosuria, it should be continued; if it does not, it should be restricted. Nervous strain of any kind, whether vocational or domestic, should be eliminated as far as possible. Nothing can do more damage to the diabetic than worry or nervous shock. The following case is cited to illustrate this point:

| Date. | Carbohydrate intake. | Glucose in urine. | Carbohydrate balance. | Remarks. |
|---|---|---|---|---|
| Aug. 22..... | 68 grams | 0 grams | +68 grams | Nervous shock results in negative carbohydrate balance. |
| Oct. 3..... | 50 grams | 0 grams | +50 grams | |
| Oct. 24 ..... | 75 grams | 96 grams | −21 grams | |
| Oct. 31..... | 30 grams | 43 grams | −13 grams | |

*Cures.*—Carlsbad, Neuenahr, and Vichy offer opportunities for a free and well-regulated life to the diabetic. In contradistinction to the ordinary hotel, at none of which diabetics seem to be able to obtain a proper diet, the food is especially prepared and regulated according to the physician's orders. Mild cases do very well at these resorts the severer ones often do poorly. Many patients are mistaken in believing that a cure at one of these watering places justifies the transgressions of the limitations of their diet during the remainder of the year, and thus do themselves serious harm.

*Patent Foods.*—These are without number, and very few of them are of any value.[17,18,19] None of them should be ordered by the physician until he has satisfied himself as to the carbohydrate content of the product in question.

The following is a list of such foods which the author has found to be of service:

Akoll biscuit, Huntley and Palmer carbohydrate, 2.7 per cent. Each biscuit weighs about 5.1 grams and contains 0.14 gram carbohydrate (author's analysis).

Casoid biscuits and flour, to be had of Thomas Leeming and Company, New York City. Some of these products are starch-free, while others contain a minimal quantity.

* Of these, the one devised by S. R. Benedict[15] has the advantage of being rapid, easy to manipulate, and accurate, and requires no expensive apparatus such as the polariscope.

† Those devised by T. S. Hart.[16] are very convenient.

* The following tables are suggested as useful

Atwater and Bryant: U. S. Dept. of Agriculture, Bull. No. 28, 1906.

Locke: "Food Values." New York, 1911.

Schull and Heisler: "Nahrungsmitteltabelle." Würzburg, 1909.

Von Noorden: "Die Zuckerkrankheit." Berlin, 1912, pp. 389–402.

Fromme's Luft Brod, containing about thirty-three per cent. of starch (author's analysis). The advantage of this form of bread is that being very light and voluminous a small amount by weight gives a good deal of satisfaction.

Soy bean flour, to be had of the Cereo Company, Tappan, N. Y.; this flour contains about 10 per cent. carbohydrate.

Whiting's prepared milk for diabetics, to be had from D. Whiting and Sons, 570 Rutherford Ave., Boston, Mass. This milk may be shipped by express and will keep a month after delivery. It contains only traces of carbohydrate.

In every case of diabetes mellitus the first step in treatment is to determine the *carbohydrate tolerance* of the patient. A diet consisting of the articles given under the standard strict diet is allowed. In conjunction with this the patient is ordered to take food containing fifteen grams (0.5 ounce) of carbohydrate with each meal. This may be given as one ounce of white bread, or where the weighing of the bread will be inaccurate, three Huntley and Palmer's breakfast biscuits (each containing five grams of starch according to the analysis of T. S. Hart) or three Uneeda soda biscuits (having approximately the same starch content) which are cheap and readily obtained by any one. This diet contains about sixty grams of carbohydrate, fifteen grams in unavoidable starchy food of the diet list, and forty-five grams in the accessory bread or biscuits prescribed. On the third day of this regimen the patient collects a twenty-four hour specimen of urine. The quantity of sugar present must be balanced against the carbohydrate intake. If the output is less than the intake, a positive carbohydrate balance is present; if the converse is true, a negative carbohydrate balance.

STANDARD STRICT DIET.

*May eat:*

Soups—Clear meat broths.

Meats—All kinds of meat, fresh, smoked, or cured, except liver; all meats must be prepared without flour or breadcrumbs.

Eggs—Eggs in any form, prepared without milk, flour, or sweetening (sugar, jam, etc.).

Butter—Butter, oil, and lard.

Cheese—All kinds of cheese.

Fish—All kinds of fish, but no clams, oysters, or scallops.

Vegetables—Greens, spinach, string beans, Brussels sprouts, asparagus, lettuce, endive, cucumbers, celery, cabbage, mushrooms, tomatoes, sour pickles.

Desserts—Gelatine jellies (use sour white wine, brandy or coffee for flavoring), custards made with cream only (without milk), and sweetened with saccharine (do not use sugar).

Beverages—Tea and coffee, sweetened with saccharine (without sugar or milk); claret, burgundy, sour white wine, and whiskey in moderate amounts. Vichy water. Thick cream, four ounces (one-half tumbler) a day, to be used with tea or coffee, or as desired in cooking.

Condiments—Pepper, salt, mustard, oil, vinegar.

*Must avoid eating:*

Sugar in any form. Bread, biscuits, and cakes of all kinds. Toast, crackers, rice, oatmeal (and all cereals); sago, tapioca, macaroni, vermicelli, potatoes, carrots, parsnips, beets, corn, beans, peas. All fruits, fresh, preserved, and dried. Jams and jellies. Pastry, puddings, and ice-cream. Sauces and gravies thickened with flour.

*Must avoid drinking:*

Milk, ales, porter, stout, beer, cider, all sweet wines, port wine, liqueurs, sparkling wines, syrups.

(For patients in an advanced stage of the disease as manifested by emaciation, weakness, digestive disturbances, or acetonuria, more than sixty grams of carbohydrate should be allowed in the preliminary test diet, and a teaspoonful of bicarbonate of soda after each meal should be ordered.)

*Mild cases exhibiting no glycosuria after the ingestion of sixty grams of carbohydrate.* In these instances more starchy food is allowed by degrees until sugar again makes its appearance in the urine. The daily ration of starchy food is then put somewhat below the maximum tolerated. One day a week of adherence to the standard strict diet is a great aid in keeping the urine free from sugar. The foods allowed need not be bread or biscuits, but equivalent amounts of any of the starch-containing articles of diet may be used. The exact quantities should be indicated by the physician. The personal tastes of the patient afford the best guide as to what form of starch is most desirable. Next to bread the fresh fruits usually give the greatest satisfaction. About once a month the patient's tolerance should be tested with larger amounts of starchy food, and corresponding increases made in the dietary. In this manner the power to oxidize glucose may be materially increased. The following case is one of this kind:

CASE C, AGE 46.

| Date. | Carbohydrate intake. | Glucose in urine. | Carbohydrate balance. | Diet. |
|---|---|---|---|---|
| Dec. 5 | 60 grams | 0 grams | + 60 grams | Standard strict + 3 slices bread. |
| Dec. 19 | 75 grams | 0 grams | + 75 grams | Standard strict + 4 slices bread. |
| Jan. 2 | 90 grams | Trace | + 90 grams | Standard strict + 5 slices bread. |
| Jan. 30 | 75 grams | 0 grams | + 75 grams | Standard strict + 4 slices bread. |
| Mch. 18 | 90 grams | 0 grams | + 90 grams | Standard strict + 4 slices bread and 1 apple. |
| May 20 | 110 grams | 0 grams | +110 grams | Standard strict + 4 slices bread, 1 apple, and 1 orange. |
| Aug. 1 | 110 grams | Trace | +110 grams | Same diet. |
| Sept. 5 | 75 grams | 0 grams | + 75 grams | Standard strict + 4 slices bread. |
| Oct. 3 | 85 grams | 0 grams | + 85 grams | Standard strict + 3 slices bread and 1 5 apples. |
| Nov. 19 | 125 grams | 0 grams | +125 grams | Standard strict + 5 slices bread, 1 apple, and 1 orange. |
| Apr. 1 | 155 grams | 0 grams | +155 grams | Standard strict + 6 slices bread, 2 apples, and 1 orange. |
| May 27 | 175 grams | Trace | +175 grams | Standard strict + 6 slices bread, 2 apples, and 2 oranges |

*Mild cases exhibiting glycosuria after the ingestion of sixty grams of carbohydrate, but still retaining a plus carbohydrate balance.* Such patients usually show only traces of acetone or diacetic acid, if any. These small amounts of acid bodies may be disregarded and attention focussed on the glycosuria. The carbohydrates should be gradually diminished until the glycosuria disappears and then slowly increased as the sugar tolerance improves. At times more energetic measures are required to render the urine sugar-free. These are detailed in the next section. The appended chart illustrates the type of case under consideration:

Polyuria, thirst, and marked itching disappeared in the patient, within a few days after the treatment was begun. This improvement occurred in spite of the fact that small quantities of sugar were present in the urine. This is frequently seen.

Case S, Age 54.

| Date. | Acetone. | Carbohydrate intake. | Glucose in urine. | Carbohydrate balance. | Diet. |
|---|---|---|---|---|---|
| Jan. 16 | 0 | 60 grams | 20 grams | +40 grams | Standard strict + 3 slices bread. |
| Jan. 26 | Trace | 15 grams | 14 grams | + 1 gram | Standard strict. |
| Jan. 31 | Trace | 15 grams | 7 grams | + 8 grams | Standard strict. |
| Apr. 20 | 0 | 60 grams | 20 grams | +40 grams | Standard strict + 3 slices bread. |
| Apr. 27 | 0 | 30 grams | 0 grams | +30 grams | Standard strict + 1 slice bread. |
| May 4 | 0 | 60 grams | 0 grams | +60 grams | Standard strict + 3 slices bread. |
| Aug. 22 | 0 | 75 grams | 0 grams | +75 grams | Standard strict + 3 slices bread and 1 orange. |

*Cases having a negative carbohydrate balance moderately severe* in character.* These patients show marked reactions for acetone and diacetic acid in the urine. The quantitative determination of ammonia is almost indispensable as a therapeutic guide. If the ammonia excretion is above one gram, bicarbonate of soda should be administered until the ammonia is reduced to that amount or below it. In cases of moderate severity, such as are now under consideration, the ammonia never rises much above two grams per day; such cases should be considered as more severe than those that fall under this category. (When ammonia estimations cannot be obtained, bicarbonate of soda may be administered in sufficient amount to make the urine neutral or alkaline. If such a reaction can be obtained, there is no danger of acidosis.) The simple presence of even marked qualitative reactions for the acid bodies affords no contraindication in the moderately severe cases to restriction of the carbohydrates in order to render the patient sugar-free. Using the standard strict diet is not sufficient to accomplish this as in the types of diabetes previously discussed, and more energetic measures must be resorted to. These are the restricted protein diet and the green day diet as detailed in the tables. The restricted protein diet eliminates all unnecessary nitrogenous food, which, as has been previously shown, may give rise to glucose. In every instance this diet necessitates weighing of the food. If the patients are not intelligent or conscientious enough to do this, as is often the case, a competent nurse should be put in charge or the patient should be sent to a hospital or sanatorium. The restricted protein diet may be continued for a long time, since it provides sufficient calories for adequate nourishment.

Restricted Protein Diet.†

*Breakfast:*
Coffee with one and one-half ounces cream.
Two eggs.
One-half ounce bacon.
Two-thirds ounce butter.

*Luncheon:*
One egg.
One-half ounce bacon.
Two ounces meat.‡
Salad with one-half ounce oil.
Vegetables‡ with one-half ounce butter.
Six ounces sour white wine or claret, or one ounce whiskey or brandy.
One-half ounce butter.

*Afternoon tea:*
Tea with one-half ounce cream.

*Dinner:*
Any clear soup.
Three ounces meat.‡
Salad with one-half ounce oil.
Vegetables with one-half ounce butter.
One ounce cream cheese.
Wine, whiskey, or brandy, as at luncheon.
Demi-tasse of coffee.
One-half ounce butter.

(This diet contains approximately ten grams of nitrogen and 2,500 calories.)

The green-day diet was devised by von Noorden with the idea of limiting the food intake as much as possible; the condition brought about is one of semi-starvation. This diet should not be prescribed for more than one or at most two successive days. Frequently while using it a half day rest in bed is indicated. Inasmuch as the only hope of the diabetic lies in restricting the glycosuria, a measure of this severity is fully warranted. From one-half to one ounce (fifteen to thirty grams) of bicarbonate of soda should be ordered for the green-day period.

Green Day

*Breakfast:*
One egg, boiled or poached.
Cup of black coffee.

*Dinner:*
Spinach with a hard-boiled egg.
One slice of bacon (this should weigh one-half ounce).
Salad, with one tablespoonful of oil.
Three-fourths of a water glassful of sour white wine or claret, or two tablespoonfuls of whiskey or brandy.

4.30 *P.M.*
Cup of chicken broth, bouillon, or tea.

*Supper:*
One egg, scrambled, with tomato and a little butter.
One slice of bacon (this should weigh one-half ounce).
Cabbage, sauerkrout, string beans or asparagus, canned or fresh, in any quantity desired.
Cup of tea, without milk or sugar.

The methods and results of the treatment just outlined are seen in:

Case N, Age 50.

| Date. | Acetone. | Diacetic acid. | Carbohydrate intake. | Glucose in urine. | Carbohydrate balance. | Diet. |
|---|---|---|---|---|---|---|
| Aug. 21. | +++ | ++ | 45 grams | 90 grams | −45 grams | Standard strict + 2 slices bread. |
| Aug. 24. | + + + | + + | 15 grams | 33 grams | −18 grams | Standard strict. |
| Aug. 28. | ++++ | ++++ | 5 grams | 3 grams | + 2 grams | Green day. |
| Aug. 29. | ++++ | ++++ | 10 grams | 8 grams | + 2 grams | Restricted protein. |
| Aug. 31. | ++++ | ++++ | 10 grams | 6 grams | + 4 grams | Restricted protein. |
| Sept. 2. | ++ | ++ | 10 grams | 3 grams | + 7 grams | Restricted protein. |
| Sept. 3. | ++ | ++ | 10 grams | 0 grams | +10 grams | Restricted protein. |
| Sept. 13 | + | 0 | 10 grams | 0 grams | +10 grams | Restricted protein. |
| Sept. 24. | 0 | 0 | 17 grams | 0 grams | +17 grams | Restricted protein + 1 slice bread. |

* Cases of moderate severity are those which can be rendered sugar-free on a restricted protein diet or by the use of green days.

† Adapted from Janeway,[20] T. C., American Journal of Medical Sciences, 1909, cxxxvii, 113.

‡ The vegetables and meat should be restricted to those kinds allowed on the standard strict diet list.

The improvement of the carbohydrate tolerance in this patient is self-evident. The acetone and diacetic reactions demand further comment. Many physicians are afraid to limit carbohydrate food in subjects with these indications of acidosis. Discriminating care must be exercised, but the idea should not be given up without further consideration. In the present instance, quantitative ammonia determinations on August 21 and 24 were 0.9 and 1.1 grams respectively, thus stamping the acidosis as of mild degree in spite of the strong qualitative reactions. Subsequent results proved this assumption to have been correct, since on September 24 the acid bodies had entirely disappeared from the urine. It should be borne in mind that a case which has been on a liberal diet will develop an acidosis when the carbohydrate food is restricted, and that the body gradually develops the power to metabolize beta-oxybutyric acid along normal lines and the acidosis consequently has a tendency to diminish. This is true even when there is no increase in the carbohydrate tolerance. The type of case under consideration here is one in which the aim of treatment is purely to limit the formation of acid bodies; to aid their elimination is a secondary consideration.

*Cases having a negative carbohydrate balance of the markedly severe type.* In these patients it becomes impossible in most instances to restrict the starchy food, on account of the ever-increasing acidosis. Occasionally this may be accomplished by measures such as those already indicated, and the case becomes a moderately instead of a markedly severe one. Bicarbonate of soda should be given in sufficiently large quantities to keep the ammonia below three grams a day. It is best given in Vichy water. Most patients are able to take thirty, and some as much as forty-five grams of the drug daily for considerable periods of time. Finally, the oatmeal diet of von Noorden presents an opportunity to benefit these cases. One or two green days should precede and follow three or more oatmeal days. In favorable subjects the result is a diminution in the acidosis and an increase in the sugar tolerance, but not all patients react favorably, and sometimes the treatment has to be cut short. These so-called oatmeal cures may be given as often as they are productive of beneficial results. A very good plan is to have a definite dietary cycle somewhat as follows:

One week standard strict diet+100 grams carbohydrate
One week standard strict diet
One week oatmeal cure
One week standard strict diet
Repeat this order of events.

Innumerable combinations suggest themselves. If possible, the glycosuria should not be allowed to exceed fifty grams a day, and the patient's weight should be maintained.

### Oatmeal Diet.

Eight ounces (one-half lb.) oatmeal, eight ounces (one-half lb.) butter, six eggs.

Cook the oatmeal thoroughly in water for two hours. The butter and eggs must be well stirred in when the oatmeal is nearly done. Use salt as desired.

This constitutes the food for one day. It may be eaten as gruel, mush, or fried mush. It should be divided into seven equal parts, one part to be taken every two hours.

Two cups of black coffee, and three-fourth of a water glassful of sour white wine or claret, or two tablespoonfuls of whiskey or brandy may be taken throughout the day.

*Treatment of Complications.*—It must be borne in mind that most of these are probably the result of hyperglycemia, or are at least unfavorably influenced by its presence. Tuberculosis, perforating ulcers, gangrene, neuralgias, pruritus, carbuncles, etc., all fall under this category. The treatment, therefore, consists primarily in reducing the glycosuria and hyperglycemia, and secondarily in the local treatment accorded to such conditions whenever they occur.

*Treatment of Coma.*—In cases that have been carefully treated, the advent of coma usually leaves very little chance for recovery; in those that have had inadequate care there is frequently a chance to rescue the patient from the attack and to prolong life for a considerable period.

The diet should contain carbohydrate in considerable quantities. Milk is generally the most suitable article of food. Levulose may be administered by mouth or rectum.

The bed should be well warmed and stimulants and diuretics given as indicated. In the early stages of coma, when there may be much distress from vomiting, narcotics often seem to be the only measures that will afford relief. They should be used only after due consideration of the fact that they will in almost every case have a very unfavorable influence on the general condition of the patient.

The sheet anchor of treatment is in the giving of alkalies. Bicarbonate of sodium should be administered in as large quantities as possible by mouth and rectum. An intravenous infusion of a four per cent. solution of sodium carbonate often produces a marvellous effect in resuscitating a patient The infusion may be repeated in six hours.

Herman O. Mosenthal.

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**Diacetic Acid,** $CH_3.CO.CH_2COOH$, aceto-acetic acid, is a colorless strongly acid compound found in the urine and blood associated with $\beta$-oxybutyric acid and acetone in conditions of acidosis accompanying diabetes, starvation, etc. It may be formed from $\beta$-oxybutyric acid and in turn it gives rise to acetone, in accordance with the following reactions:

$CH_3.CH.OH.CH_2.COOH$ + oxidation = $CH_3.CO.CH_2COOH$
$\beta$-oxybutyric acid — Diacetic acid

$CH_3.CO.CH_2.COOH$ + oxidation = $CH_3.CO.CH_3$
Diacetic acid — Acetone

See also *Acidosis*.

Frank P. Underhill.

**Diagnosis, Physical.**—There are four cardinal principles of physical diagnosis always to be borne in mind: (1) Time, (2) thoroughness, (3) thorough knowledge of the normal, and (4) careful interpretation of the findings. There are four basic measures employed: (1) *Inspection*, (2) *palpation*, (3) *percussion*, and (4) *auscultation*.

For examination, if the patient is a male he should be stripped bare to the waist, if a female, modesty may demand some light covering, but in doubtful or special cases even this should be removed and it is very rarely that the sincere physician meets any real objection to such a procedure when there is a need for it; and it may be added the cases are few where a need does not exist. The examination should proceed in an orderly, regular manner, and it is a matter of greatest concern that every point be noted whether at the time it seems to have any bearing upon the condition or not. It is a very doubtful economy of time that prompts one not to make a full set of notes on each case.

Inspection.—*Head.*—When inspecting the head we first note the size and shape. A large head is to be distinguished from an abnormally large head by comparison with the rest of the physical make-up. If a head is abnormally large it may mean hydrocephalus or rickets, in children. In an adult it is associated with osteitis deformans. In children one always notes the condition of the fontanelles. If open past the normal closing time (the posterior should close in about six or eight weeks, and the anterior about eighteen months after birth) one should be suspicious of hereditary syphilis, cretinism, or one of the two conditions mentioned above.

The *hair* is noted as to its condition of nutrition. An abnormally dry hair is found especially in cretinism and myxedema and oily hair in the various seborrhoic conditions. Favus should also be borne in mind as well as the other skin diseases apt to be found.

In considering the *face* it is better to view the face as a whole before taking up specially the various parts. One can obtain a great deal of information from the expression. The drawn face with contracted brow and flattened lips is familiar to all as a picture of pain. The aptly termed sardonic grin if once seen is never forgotten. An edematous face of advanced nephritis is easily recognized by its edema and the peculiar yellowish-white appearance and often cyanosed membranes; this face is often seen also in the later stages of broken compensation in heart disorders. It is not to be mistaken for the fat, flaccid face of myxedema, the fact that the skin is very dry and does not pit on pressure and the associated symptoms of thyroid insufficiency will serve to differentiate. The huge prognathous jaw, prominent supraorbital ridges, prominent cheekbones, large nose, and large ears are all constant in the faces of acromegaly. The dropped lower jaw, pinched nose, dull eyes and usually prominent ears with more or less protrusion of the front upper teeth all point at once to adenoids. There is also to be remembered the mask-like face of paralysis agitans in which one sees no change of expression at all. The startled look of exophthalmic goiter with the very prominent bulging eyeball; the leonine face of leprosy with its overabundance of flesh: the sunken-cheeked, drawn, usually pasty complexioned face of tuberculosis; the red-nosed, heavily colored, smooth-skinned face of alcoholism; the heavily cyanosed-appearing face due to silver nitrate, not seen very often now but common when this treatment was in vogue for epilepsy.

One should scan the face closely for old scars. Very often the old scars left by a secondary syphilide afford a means of clearing up an obscure diagnosis. These must not be confounded, however, with the pitting from chicken-pox and smallpox.

*The Eyes.*—The size and equality of the pupils are always to be noted and the position of the eyes at rest. The motility of the eyes must be tested by having the patient look in various directions. The reaction of the pupils to light and accommodation is to be tested. Argyll-Robertson pupil is found as a constant sign in tabes dorsalis and progressive paralysis and is a very good sign. It is very valuable. It consists in a preservation of the pupillary reaction to convergence and accommodation while the reaction to light is lost. It is not of a necessity accompanied by any impairment or loss of vision. The color and condition of the sclera should be looked into and any deviation from the normal clear white glaze should be noted. Just in this connection must be remembered an examination of the cornea for any ulceration or abrasions. The cornea at times also presents around its periphery a white-grayish ring which is one of the classical signs of senility and arteriosclerosis—arcus senilis. An irregular distributed haziness, at times a total haziness, so-called steamed look of the cornea—interstitial keratitis—may be the only evidence of syphilis, especially of the congenital form. There may also occur as a sign of lues an eye that, if no other cause for its appearance is found, is of some value, namely, an unilateral ptosis. This is due, of course, to paralysis of the third nerve. There is seen occasionally in the various neurotic or psychoneurotic conditions a moderate bilateral ptosis, but this is more or less unreliable as it must be remembered that the height to which the eyelid is raised is a relative factor and depends upon the individual. Tuberculous, luetic, and epidemic forms of meningitis often occasion strabismus. Brain tumors may also cause squint. A rapid horizontal or vertical movement of the eyeball, consisting of very short excursion, is seen in multiple sclerosis and other brain lesions. The proper term for this phenomenon is *nystagmus*. It is also frequently noted in exophthalmic goiter. In an article of this nature it is hardly fitting that the retinal examination should be discussed. It is mentioned only to impress upon the reader the extreme importance of every practitioner of medicine familiarizing himself with the ophthalmoscope and learning thoroughly the normal eye-ground, or retinal picture, and the various pathological deviations therefrom. In many diseases an intelligent examination of the retina will give us our first clue to an accurate diagnosis; for instance, there may be mentioned nephritis, diabetes, and certain intracranial affections. One is reluctant to leave the discussion of the eye as a diagnostic aid. There is hardly another organ in the entire human economy that will prove of such great aid in so many general disorders and that will give such accurate, complete, and real information. It is in many cases truly a window in which one may look and find much to repay him for the look. Its great importance cannot be too strongly emphasized if one would be a careful diagnostician.

*Ears.*—The ears should in every case be examined for tophi. These are little deposits of urate of sodium in the soft parts of the ears and are distinct manifestations of gout. It is also important to examine for any discharge from the external ear. The canal should be explored to ascertain its patency, the presence of any furunculosis or other inflammatory processes. At the same time it is always well to make pressure over the mastoid process to elicit any tenderness that might presuppose trouble in the mastoid cells. This is especially important in children who have attacks of earache.

*Nose.*—The general contour of the nose is first studied. Remembering that the falling in of the bridge of the nose without other assignable cause is usually of luetic origin; that the delicacy of outline is often lost in myxedema; that the nose is pitched and inclined upward, usually, in adenoids, that the

whole sum and substance is markedly enlarged in acromegaly; and finally that a red nose does not *always* mean alcoholism for it may mean acne rosacea, lupus erythematosus, and is seen frequently in arteriosclerosis. The next point noted is the behavior of the alæ nasi. These little side flaps of the nose should not move in ordinary breathing. And while not in every individual to be so interpreted, in the great majority of cases a movement of the alæ nasi with respiration is indicative of labored breathing, pneumonia, etc. The patency of each nostril is to be investigated and the position of the septum ascertained. Ulcers are to be looked for on the septum and if found their etiology should be carefully investigated. A nasal discharge if chronic may mean, in an infant, lues. An acute nasal discharge should be considered in the light of a possible diphtheria, influenza, or other infective process. Any ulcer of the skin covering the nose, more especially if chronic, should always be regarded as tuberculous or malignant until proven otherwise.

*Mouth and Throat.*—The lips are naturally first noted. Any pallor or cyanosis is noted and its cause looked for. Pallor may be due to anemia, fright, or weakness. Cyanosis is caused by heart disorders, lung disorders, and certain poisonings. It is also seen in amyloid degeneration of the kidneys. Sores at the corners of the mouth, if not caused by colds of long duration in children, are probably syphilitic. In adults there are often seen white linear scars radiating from the corners as the results of healed lesions of syphilis. Herpes seen in typhoid and other diseases should not be mistaken for the conditions just mentioned. The acute process usually serves to differentiate. Within the lips are seen just at the mucocutaneous junction the so-called mucous patches of syphilis. The teeth are to be inspected as to their condition and number absent. The tongue as to its size and shape and the presence or absence of a coating and the character of the coat if present. The throat is to be examined for enlarged or diseased tonsils, adenoids, pharyngitis, laryngitis, etc.

In inspection of the *neck* one notes the size, shape, and symmetry. The presence or absence of abnormal pulsations, enlarged glands, and tracheal tug. The position of the thyroid, its size and consistency are noted. The thymus may be mapped out by Bogg's method. If any pulsating masses are seen their location is to be definitely described in the case-notes. There is immediately above each clavicle a depression or fossa, spoken of as the supraclavicular as distinguished from one just below the clavicle called the infraclavicular fossa. The supraclavicular fossa is to be inspected for any abnormal depth or size and any abnormality found is to be considered in connection with the general findings and may thus acquire some importance. For instance, these fossæ are almost universally deepened in tuberculosis. The depth of these fossæ naturally accentuates the prominence of the clavicle and, indeed, this prominence of the clavicle is usually the first thing to strike one in an inspection of the chest.

*Chest.*—In inspecting the chest we first examine the respiratory movements, their rhythm, depth, frequence, and the type of breathing present. By type we distinguish three kinds of respiratory movements as related to the general organism: (1) Upper costal, (2) lower costal, (3) abdominal.

1. This is the type in which the chest movements during inspiration and expiration are confined almost entirely to the upper portion of the chest with little expansion of the lower thorax and hardly a protrusion of the abdomen. Elevation of the sternum is seen on quiet breathing whereas in the other types it is seen only on deep breathing. Upper costal breathing is increased by edema, inflammations, consolidations, and adhesions in the lower thorax; interference with rib motion, fractures, Pott's disease, etc.; any intraabdominal condition that prevents full excursions of the diaphragm.

2. In the normal adult (male) the lower costal type of breathing is seen. It is a movement of the lower five to seven ribs and some abdominal movement due to diaphragmatic excursions. Lower costal breathing may be increased by edema, inflammations, consolidations, adhesions in the upper thorax, and aneurysm.

3. This type is the normal type usually seen in children and is almost wholly abdominal with a slight lower costal element.

Disturbances in frequency of the respiratory movements are very important. The movements are increased in lung diseases lessening the total functionating area. In cardiac diseases, blood disorders, nervous disorders, fevers, etc., the movements may be diminished as result of diseases of respiratory muscles, painful conditions in and around the thorax and abdominal diseases of certain types. In certain conditions another disturbance to be encountered, though this is more frequently detected by auscultation than inspection, is an abnormal shortening of the inspiratory murmur with a marked prolonging of the expiratory time. The inspiratory and expiratory movements should bear the ratio of five to six, the expiratory being slightly longer. Either movement may be affected not only as to length but as to character, becoming short, jerky, and spasmodic, the so-called "cog-wheel" breathing. "Cheyne-Stokes" breathing is a peculiar type in which there is a regular definite cycle of irregular breathing. One or two shallow respiratory movements are followed by four to six that gradually increase in frequency, depth, and noise until a climax is reached and then they gradually subside to recur again at regular intervals after a pause between each series of rises and falls. This occurs in certain cerebral, cardiac, and renal involvements. It is generally regarded as highly unfavorable. There is to be noted especially any "lagging" of one side or the other. Both sides should show the same degree of expansion; one must note sunken places or bulgings as seen in aneurysms, pericardial effusions, etc. Next after the respiratory phenomena one notes the shape and size of the thorax as a whole.

*Pathological Chest Types* (after Le Fevre).—1. The barrel-shaped or emphysematous type. Here there is an increase in all diameters of the chest, especially in the anteroposterior. The position is one of full-forced inspiration, the neck is shorter, the scapulæ are thrown upward, outward, and forward and project from the thorax.

2. The phthisical, paralytic, alar, or pterygoid chest. Here we have an abnormal flattening of the ribs so there is a distinct decrease in the anteroposterior diameter and an increase in the lateral diameter. The neck is lengthened, the chin projects forward and the angle of the clavicle with the scapulæ and sternum increases the depth of the supraclavicular fossa.

3. The rachitic types. In the simplest form there is a flattening laterally of the chest in the lower segment while in the upper segment the sternum is carried forward and the ribs are more or less straightened, so that the anteroposterior diameter is increased above while at the same time the lateral is diminished below. There are many variations between this chest and the extreme rachitic chest known as pigeon-breast, in which the ribs are so straightened at their connections with the cartilages that the chest appears almost triangular. In considering rachitic chests mention should be made of Harrison's groove. This is a well-marked furrow or groove beginning near the junction of the fifth rib with the sternum and running obliquely outward and downward and backward. We will not consider here the finer diagnostic points to be found in the different unilateral enlarge-

ments and depressions of the thorax. Any bulging or flattening of the cardiac area should be carefully noted, and cognizance taken of a diffusion of the heart impulse over a wide area. The apex beat should be carefully located and noted. Pulsations at the base of the heart or a drawing in of any part of the precordial area with pulsation are important signs. Dilated veins must especially be noted as indicative of obstructed return flow due to pressure upon the venæ cavæ or some other cause. Bulging of the precordia is sometimes caused by cardiac disease, more often it is from some other cause, scoliosis, abscess, pleural effusion, aneurysm, etc. Flattening may mark a dry or fibrinous pericarditis as bulging may signify a pericarditis with effusion. On the other hand flattening may be due to retraction of the lung. The apex beat is located in the fifth or sixth intercostal space to the left near the mammary line and is limited to an area about one inch in diameter. Its position may be changed (1) in those rare cases of dextrocardia where the apex lies to the right; (2) it may be pushed away by visceral changes other than the heart, lung retractions, abdominal tumors, pneumothorax, aneurysm, pleural effusion, etc. In diseases of the heart, dilatation, it is mostly outward,; upward somewhat with pericardial effusion unless effusion is large enough to disseminate impulse; outward and downward in left ventricle hypertrophy.

The *abdomen* is to be inspected as to its general contour, fullness, swelling, protuberance, sinking or retraction, local bulgings, pulsations, and any movements. In a full abdomen one must remember the classic, that "fullness may be due to fat, fluid, flatus, or fetus." If the bulging is local the particular location is to be described and its connection with ovaries, tubes, appendix, spleen, gall-bladder, or other organ considered.

Epigastric pulsation may mean venous pulsations in the liver, distention of the right ventricle of the heart, aortic pulsation, or aneurysm. The abdomen usually rises and falls with respiration, bulging during inspiration and falling with expiraton. In paralysis of the diaphragm the reverse is true. Abdominal movements are absent in peritonitis. The peristaltic waves may be visible and are seen in cases of intestinal obstruction and dilated stomach or colon. Distended veins are to be noted if they occur for the same reason as distended veins on the thorax.

The genitals should always be inspected for old scars, adherent prepuce, condylomata, cystocele, rectocele, etc. The lower and upper extremities are to be inspected for enlarged veins, local swellings, old syphilitic scars, enlarged joints, equality in size and length of two sides, etc.

Palpation.—The most important finding in palpating the head and neck will be the presence or absence of enlarged postcervical glands, size of the thyroid, exact location of any local bulging or swellings that might be aneurysms, abscesses, or malformations. The chest is to be palpated for pulsations, vibrations, tenderness, and fluctuation. The pulsations and the extent of the apex impulse is first noted. This may be heaving in character as seen in left ventricle hypertrophy; the sharp slap of the irritable heart; the feeble tap of the weakened or fatty heart; or the impalpable apex beat of the thick chest wall, feeble heart, or emphysema. Any thrills or vibrations are to be noted. These have been described elsewhere in the artical on *Cardiac murmurs.*

Any tender spots should be carefully palpated and an effort made to decide whether it is an inflammatory condition of the chest wall, an intercostal neuralgia, an intercostal myalgia or a deep-seated abscess. Fluctuation occurs in abscesses of the chest wall either occurring primarily in the bones or soft parts or due to pus burrowing through from an empyema.

In detecting vibrations the palm of the hand flat upon the chest is the technique usually taught. The writer, personally, prefers the method of Minor: allowing the inner surface of the hand and little finger to rest lightly but snugly upon the part. With this method he has detected increased fremitus that was not perceptible with the palm. Fremitus, independent of the voice sounds, may be due to pleural friction, catarrhal changes in the mucosa of the bronchi, constrictions, fluids in the bronchi or pulmonary cavities.

Vocal fremitus is caused by the voice sound vibrations being transmitted from the larynx to the chest wall by the trachea, bronchi, and lung tissue. Any impeding substance along this course will naturally affect the intensity of the fremitus. To test this the patient is instructed to repeat in a clear monotone, "one, two, three," or "nine hundred and ninety-nine." It is to be noted if the vibrations detected in corresponding parts of the two lungs are the same in intensity and whether they are increased or diminished from normal. Vocal fremitus is increased when the voice note is of a deep pitch; when the chest walls are rigid or thin; when an area of lung is consolidated or has a cavity near its surface. Due to the anatomical formation, fremitus over the right lung is slightly greater than over the left. Fremitus is diminished in high-pitched voices, thick-walled chests, thickened pleura, pleural effusions, lessened expansile ability of lung, etc.

In palpating the abdomen note should be taken of the presence or absence of pulsations, tenderness, rigidity, swellings, and gurglings. The ability to palpate the liver and spleen should always be noted as this is abnormal. The lower part of the right kidney can at times be palpated but the ability to palpate the entire kidney of either side is to be regarded as pathological. Normally the abdomen is relaxed and feels doughy. Any increase in resistance should direct attention to some intraabdominal inflammatory condition, unless it can be satisfactorily accounted for by nervousness of the patient; and should one decide it is nervousness or fear, every effort should be made to dispel this and then note taken as to whether the resistance disappears. General peritonitis gives almost a board-like rigidity to the abdomen. The degree of resistance of the two sides should be noted. In gall-bladder and appendical inflammations the rigidity is much more marked on the right side. Normally palpation of the abdomen is painless and any tender spots should be investigated for the exact extent and point of maximum intensity. If a tumor is found it should be determined first whether it is in the abdominal wall or the abdominal cavity. If it be intraabdominal its characteristics as to size, shape, consistence, pulsations, origin, and nature of surface are to be studied. Remembering always every pulsating, rounded, smooth mass is not an abdominal aneurysm, and remembering also that many fibroids are diagnosed pregnancy and many pregnancies are diagnosed fibroids. It should be noted whether the tumor moves with respiration; if so, can it be held down when it descends. Liver and spleen tumors move and cannot be held down. Gastric tumors can.

If splashing is heard it may mean a dilated stomach if elicited several hours after taking food and heard over the stomach. Gurgling is caused by gas and fluid passing through constrictions. The umbilicus should always be examined for infiltration as it is early involved in malignancy of the liver. The extremities are to be palpated for enlarged glands, thickened periosteum, fixed joints, muscular atrophies—or tender places along nerves.

Percussion.—The information to be derived from percussion consists in detecting the boundaries of the heart and surrounding viscera and the presence of certain abnormal conditions of the pulmonary and vascular systems and intraabdominal conditions, *i.e.*

pericardial or pleural effusions, areas of pulmonic consolidations, aneurysms, dilatations, etc.

The practice of percussion is based upon the physical law that a sharp tap upon any body sets up vibrations in that body and, dependent upon the length of the individual vibrations and the rapidity with which they follow each other, the note obtained will possess certain definite characteristics. This note is either a dull thud, heard over solid viscera, or a resonant note heard over air-containing viscera. These two notes have many modifications, varying in the one all the way from an absolute dullness, that is spoken of as flat, on up through degrees until it reaches a point of which the most we can say is impaired resonance; on the other the note runs from a dull boom through the various tones until it reaches a high, sharp, short note spoken of as a tympanitic. The resonant structures of the body are the air-containing organs and the bones. The bones give a peculiar characteristic note that is individual to bones. The quality of resonance in the various organs is dependent upon the amount, disposition, pressure, and subdivision of the included air and also by the tension of the walls and septa in the organ considered. The organ with the simplest air space is the stomach. There, as expected, the note is the least modified, being, as described above, short, sharp, and high pitched, tympanitic. The many subdivisions of the lung so interfere and break up the resonance that the note in the lung is much different from that of the stomach and is spoken of as lung resonance. It is a sound typically characteristic and does not simulate closely any other known sound. Each individual by practice must learn to recognize it for himself.

As mentioned above the note obtained is the result of definite vibrations. The note is markedly affected by the depth of the tissue thrown into vibration. This depends, other things being equal, on the force of the stroke. This has very important bearing and is mentioned especially just here. If two different parts of the lung are percussed with the same force, one part having a deep underlying piece of lung and the other a thin underlying piece and each over a solid organ, the two notes will be as characteristically different as when a large drum and a small drum are struck, the deep-lying lung giving a note lower in pitch, longer in duration and more resonant than the thin lung. The exact pitch, of course, depends upon the force of the stroke and the thickness of the lung. This matter becomes very practical in making an effort to locate a solid organ overlying a resonant body or one with a resonant body overlying it. When a light blow is delivered the resonance of only this thin layer is elicited and the dullness of the underlying solid viscera does not enter into and modify the note until the extreme edge of thickness is reached. On the other hand when a sharp, hard blow is struck the note goes deeper and if the resonant body overlies a solid body the resonance of the percussion note is impaired to just the extent that the forceful vibrations reach the solid viscera. There is a very distinct flatness to fluids that is quite apart from the dullness of solid areas. There is also a note between normal resonance and tympanites that approaches neither and is spoken of as hyperresonance. In addition to these notes there are also skodaic, amphoric, cracked-pot, coin sound or bell sound, and boxy.

Percussion is practised in two ways: (1) direct and (2) indirect. The direct manner consists in tapping the parts to be percussed a sharp blow with the end of one or more fingers, making the blow with the wrists and fingers and not the elbow. The finger, or in some instance a small rubber hammer is used and is known as the plessor.

In indirect percussion some substance is interposed between the plessor and part to be percussed. A flat piece of bone, ivory or vulcanite appliances of such shape and size as to fit the chest readily, or best of all the finger, so applied as to fit snugly. As soon as the blow is struck the plessor must be at once raised so as not to impair the note. It is also very important that the finger or other object placed upon the part to be percussed fit snugly and conform to its curves and variations.

*Cardiac Findings.*—There are, in percussing the heart, two main objects in view. First, to ascertain the size of the organ and second, to find out just how much of it lies uncovered by lung tissue and against the chest wall. It is here that the most striking illustration of firm and light percussion occurs. There are two portions of the heart that cannot be outlined, the base and the portion lying in contact with the liver. The great vessels at the base produce a dullness which cannot be differentiated from the true cardiac dullness and the same is true of the part in contact with the liver.

We speak of relative and absolute cardiac dullness. The relative or area of deep cardiac dullness represents very accurately the extreme outer border of the organ and is practically anatomically correct. The absolute or area of superficial cardiac dullness is that portion of the heart uncovered by lung tissue.

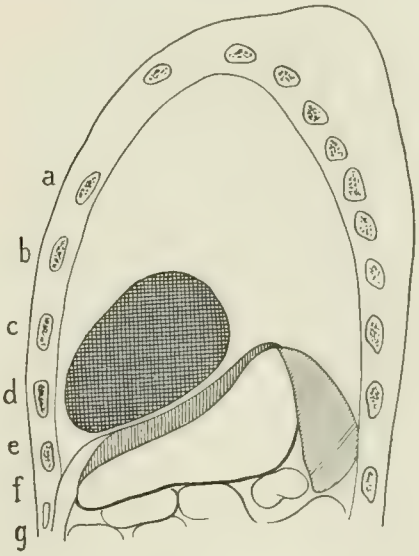


Fig. 1660.—Anteroposterior Section of the Thorax near the Parasternal Line. At *a* the resonance is full, at *b* it begins to grow emptier, at *c* it continues to grow emptier, at *d* the note is absolutely flat over the liver and heart, at *e* the stomach resonance, though muffled, may be detected, at *f* there is frank tympanites. (After Hutchinson-Rainy.)

In obtaining these two findings it is necessary to employ both methods of percussion. In finding the area of deep cardiac dullness rather fine strokes must be used lessening the intensity of force as the area of superficial dullness is approached. Fig. 1660 illustrates this point very clearly. In *a* to *b* the percussion is heavy, in *b* to *d* it is light, at *d* and *e* heavy, at *f* light.

In arriving at the area of deep or relative cardiac dullness we begin at the upper part of the left chest in the first interspace below the clavicle in a line where the inner third of the clavicle joins the outer third, and percuss downward, interspace by interspace and rib by rib, each time comparing the note obtained in the last one percussed with the note obtained above, in this way recognizing at once the first impairment of resonance and thus readily appreciate the beginning of cardiac dullness. The reason each rib is compared with the rib above and each inter-

space with the interspace is to avoid the confusion that would enter if the normal osteal dullness of the rib were compared with the normal resonance of the interspace. After finding and marking with a wax pencil the upper border of the heart we then locate the left border in the following manner. It is usual to begin in the third or fourth interspace well out toward the axillary line and percuss inward until an impairment is found when we know we have then reached the outer border (left) of the heart. In determining the right border it is customary to proceed in a like manner, remembering always to percuss from without inward. Before finding the right heart border it is wiser to outline first the upper limit of hepatic dullness in a manner similar to that used in locating the upper border of the heart. After this is found and marked, the border is then described, and not only is its outline noted but especially the angle formed by the junction of the hepatic line and the right border line is noted as to obtuseness. The usual angle is shown in Fig. 1661.

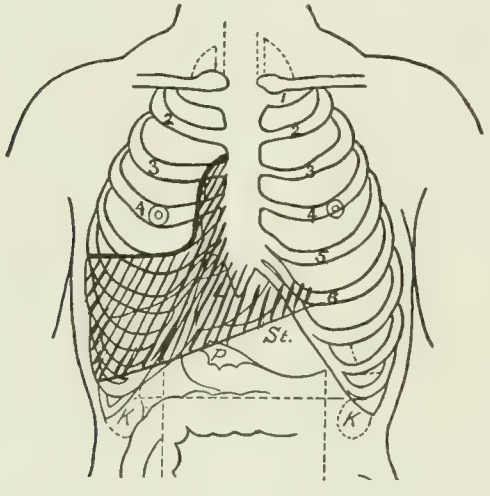


FIG. 1661.—Showing the Angle Formed by the Junction of the Hepatic Line and the Right Border Line.

There are many abnormal departures, but a very marked degree of obtuseness is to be especially noted as it is one of the most trustworthy signs in pericardial effusion and is constant. It is, of course, very difficult to set a fixed standard as the cardiac outline but in the average healthy chest it will be found as follows, for the deep or relative cardiac dullness: Upper border at the third rib or in the third interspace, in the left parasternal line. Right border is usually about three centimeters to the right of the midline, just external to the right lateral sternal line at the level of the fourth rib. It is frequently very difficult, however, to locate definitely the right border, especially if a voluminous lung covers it, and in addition percussion behind the sternum is rather unsatisfactory as the sternum acts as a sounding board and collects vibrations from the structures lying behind it. The left border in health is about in the region of the left nipple line, seven to ten centimeters to the left of the midsternal line. This border has a tendency above to curve in toward the midline and blend insensibly with the upper border so it gives a picture shown in Fig. 1662. Below, the left border makes a rather sharp turn and becomes continuous with the line of liver dullness. In the figure the shaded portion indicates the areas described.

Superficial or absolute cardiac dullness is found only by light percussion and as before stated shows the portion of the heart not covered by lung substance. The lines of percussion are similar to the ones described for the outlining the deep area of dullness. Normally the borders of the superficial dullness are found to be: for the upper border the level of the fourth rib; the left border is found to vary at its upper portions from one-half to three-fourths inch within the previously described border of deep dulness and curves outward until at its lower border it may very closely if not actually approximate the deep cardiac line. It is not possible to find the right lung border as the cardiac dullness does not correspond with the lung border. In addition the right lung runs behind the sternum to meet the left lung border. The right border extends from the fourth to the sixth costal cartilage. The left curves gradually around to be continued in the upper and joins the right at an angle, making, therefore, a triangular space.

The left side of this triangle is convex with the convexity outward. The base corresponds with the lower border of the heart. It is likewise impossible to percuss definitely the dullness of the large vessels as they lie behind the sternum. If, however, there

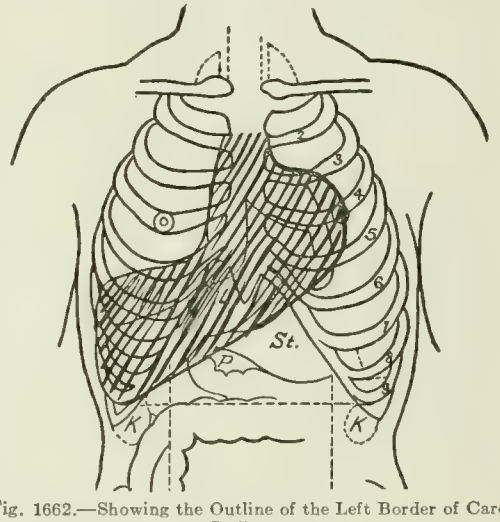


Fig. 1662.—Showing the Outline of the Left Border of Cardiac Dullness.

is a dilatation from aneurysm, aortitis, etc., a dull area can be readily mapped out. It will be continuous below and with irregular bulgings above dependent upon the shape assumed by the dilatation.

Plate XXX is to be noted in connection with the heart outlines, both normal and abnormal. It shows in a very clear graphic representation the normal heart outline, both deep and superficial dullness, and also the heart line in hypertrophy and dilitation. The reader is referred to it especially in explanation of variations from the normal areas of dullness, of an increase of dullness in a limited area which cannot be intelligently described without graphic illustration.

*Lungs.*—As mentioned above the findings to be elicited in pulmonary percussion are, the lung boundaries, the resonance, and abnormal variations. The resonance may be increased, hyperresonance. It may be diminished all the way from slight impairment to an absolute dullness, becoming flat. The hyperresonance may in some instances become so high pitched as to be tympanitic. These tones have been described above. In addition were mentioned amphoric, skodaic, cracked-pot, coin sound, and boxy. The boxy sound is that produced at times in percussing the tissue surrounding a consolidated area. The tissue in this region is relaxed and does not respond as normal lung tissue; giving on percussion an impaired resonance note, not flat or absolutely dull, but of a wooden nature.

Amphoric resonance is due to selective reenforce-

EXPLANATION OF
PLATE XXX

## EXPLANATION OF PLATE XXX.

(In all the figures the blue color indicates the superficial, and the red color the deep, cardiac dulness. The liver dulness is also indicated by the blue color.)

FIG. 1.—Area of Superficial and Deep Cardiac Dulness in Normal Conditions.

FIG. 2.—Area of Heart Dulness in Dilatation of the Right Ventricle. The increase in area of dulness is almost entirely to the right of the sternum.

FIG. 3.—Area of Heart Dulness in Dilatation of the Left Ventricle. The increase in dulness is limited to the left side of the sternum.

FIG. 4.—Area of Heart Dulness in Dilatation of the Left Auricle and Ventricle, with Uncovering of the Pulmonary Artery. (*a*) Deep cardiac dulness, right and left ventricles; (*b*) superficial dulness, left auricle; (*c*) dulness due to pulmonary artery.

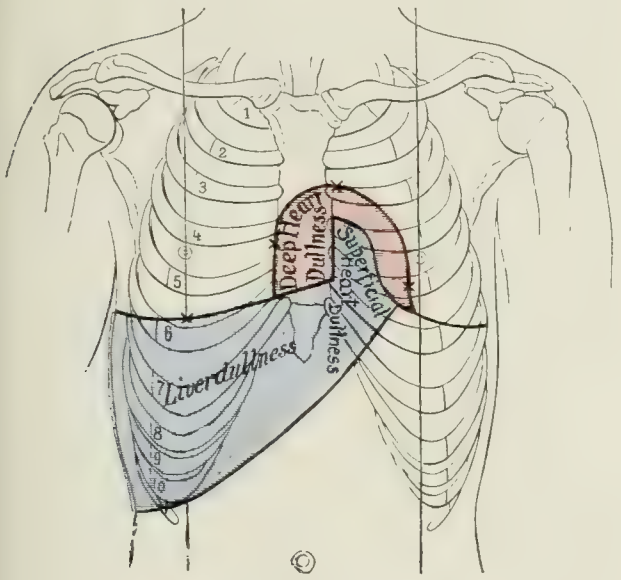


FIG. 1

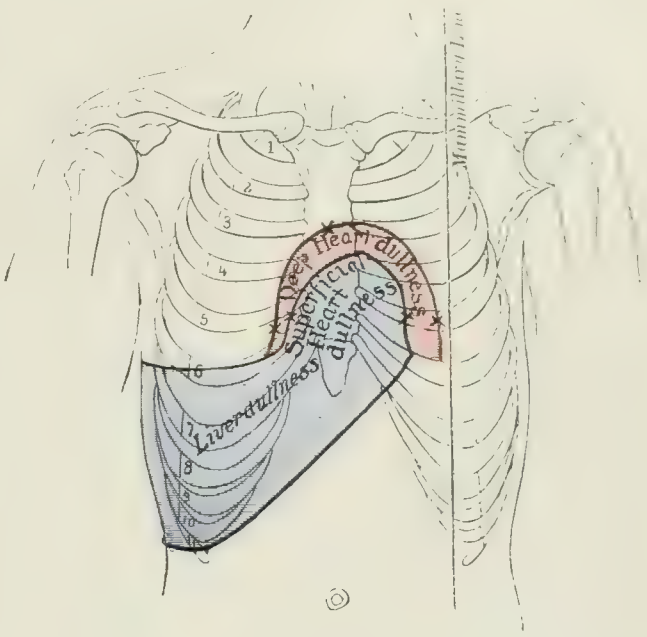


FIG. 2.

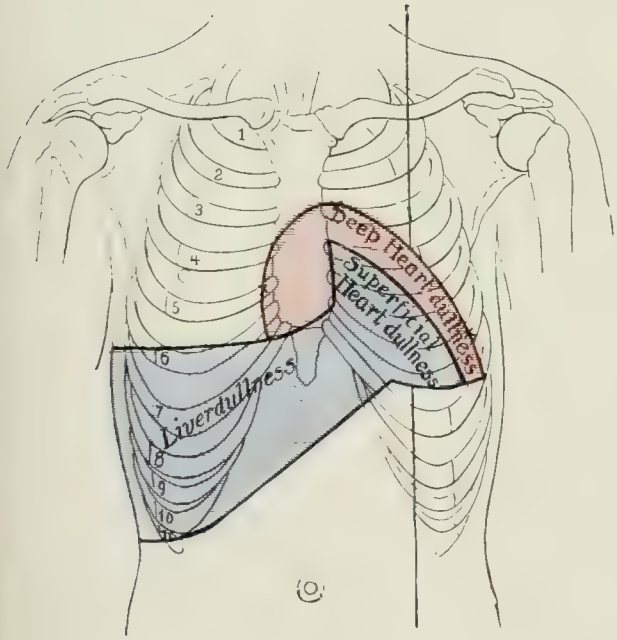


FIG. 3.

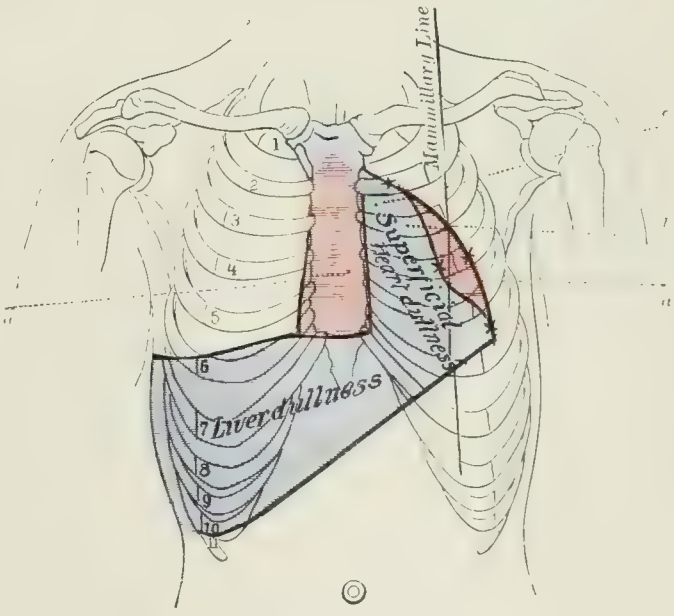


FIG. 4.

## GRAPHIC REPRESENTATION OF SUPERFICIAL AND DEEP CARDIAC DULNESS IN THE NORMAL HEART AND IN HYPERTROPHY AND DILATATION

From Sahli's "Lehrbuch der klinischen Untersuchungs-Methoden," etc.

ment of certain vibrations in a large cavity, by this means the overtones are accentuated and die out more slowly.

Cracked-pot resonance is due to a sudden expulsion of air through a constricted orifice. It occurs in percussion over a cavity which communicates with a bronchus and is more pronounced with the mouth open. It has a hissing character combined with a clinking sound.

The pitch of percussion over a cavity varies with the position of the patient. The most obvious explanation is that if the cavity be partly filled with fluid this will shift its position as the patient changes. Other factors may, however, enter. The resonance in a cavity is higher during inspiration and lowered during expiration, provided the wall is of good tension.

Skodaic resonance occurs when lung tissue becomes relaxed but still contains air. The sound here becomes distinctly tympanitic and at the same time the resonance is increased in intensity. It occurs above the level of a pleural effusion, or in the upper portion of a lung whose lower lobe is affected by pneumonic consolidation. When air has found its way into the pleural cavity, the sound is as a rule tympanitic. A characteristic form of high-pitched tympany may be heard in pneumothorax by percussion over the front of the chest with a couple of coins; one being used as plessor and the other as plessimeter, while the observer listens at the back of the chest. In very marked cases the sound is soft and chiming. In less distinct cases it has the sound of a hammer or an anvil.

*Abdomen.*—In percussing the abdomen the same cardinal principles hold as for percussion elsewhere. Percussion over the abdomen normally gives a note that is hyperresonant but not tympanitic, except over the hepatic and splenic regions and a full bladder. The pitch of the note will, of course, be influenced by the amount of air contained and the tension of the wall: *i.e.* a stomach soon after a meal will not give the same note as when empty and containing air. The two main points in abdominal percussion, however (speaking generally), are to recognize a tympanitic condition on the one hand and a loss of resonance on the other. One must remember that obliteration of liver dullness does not always signify free gas in the peritoneal cavity. A gas-distended colon is perfectly capable of intruding itself between the liver and the abdominal wall and thus obliterating all dullness in this area. Entire obliteration of the splenic dullness, on the other hand, means free gas, especially if this tympany is continuous with Traube's semilunar space.

Any dull areas found, other than the normal liver and splenic dullness, are to be noted as to their constancy with relation to various positions of the body or whether the dullness shifts as the body posture is changed.

The outlining of the gastric area is a procedure often employed, and especially in dilatation of this organ gives very valuable information. The definition of Traube's space, valuable in determining enlargements of the spleen is also determined by percussion of the fundus of the stomach. The upper border of Traube's space is formed by the lower lung border and runs in an arch from the sixth costal cartilage in the parasternal line to the ninth rib in the axillary line. The other boundaries of Traube's space are the costal margin in front below and the anterior edge of the spleen to the rear. A spleen will often encroach upon and obliterate the greater part of Traube's space when it is not readily palpable in front below the costal margin.

To determine the position of the stomach the most important procedure is the mapping out of the greater curvature. To do this the organ should be inflated. Various procedures are employed in obtaining this inflation; it is a favorite method of some examiners to use a seidlitz powder, giving the two portions separately and depending upon the gas liberated within the stomach to distend the organ. Another method, and the one the writer prefers, is to introduce a tube and inflate with a bulb to the desired size. One should be careful though and never inflate a stomach that has shown recent hemorrhage or one in which there is a definite suspicion of cancer. After inflation one should begin well toward the pubes and percuss upward either in the midline or just to the left of the midline. The lower border normally will be found at the umbilicus or about one finger's breadth above. One must bear in mind that a distended colon will give nearly the same note as the stomach. In case a desire for differentiation arises one may after outlining the stomach area and marking it while the stomach is inflated, then expel the air and fill the organ with sufficient fluid, while the tube is *in situ*, to distend it and then again percuss out the outlines and mark. If any of the previous notes were due to the colon the difference will at once become apparent. This procedure must be employed, however, only when the patient is lying upon his back.

The outlining of the lesser curvature or upper border becomes of importance in a differentiation of a ptotic stomach from a dilated stomach. The distance between the two borders should never exceed ten centimeters, normally. When this distance is exceeded then one may surely assume a dilatation present.

The lower border of the liver is determined in a manner similar to that employed for the stomach, except one begins percussion on the lower right side instead of the midline or to the left of the midline. Like stomach percussion it is then continued upward until the costal margin is reached and here normally will be found the lower liver edge. Light strokes must be used. In the midline the lower liver border is normally found about three or four fingers' breadth below the ensiform process. To be pathological the lower border must not only be either above or below the costal margin but must be associated with other signs, for, as has been pointed out, there are other factors that may enter and affect the findings. One point to be remembered in connection with abnormal liver area is the fact that a displaced liver will not freely move during respiration while an enlarged liver without displacement will. Enlargement of the liver upward with no downward enlargement is a frequent concomitant of hydatid cyst.

Percussion of the upper and anterior border of the spleen has already been mentioned in discussing Traube's space. The lower edge is defined by percussing lightly in the posterior axillary line and is normally situated about the lower border of the eleventh rib. The posterior border is found by percussing along the tenth interspace and is situated about two inches from the vertebral column. Free fluids in the abdominal cavity, or ascites, will of course give a dull note; this dullness is not, however, always absolute, for there may be transmitted the resonance from an adjacent bowel. It is always important when free fluids are suspected to outline and mark the borders with the patient on his back, then in a sitting position, and finally while lying on either side. It will be found that the fluids always gravitate to the lowest point and the air-filled intestines float to the top. An ovarian tumor or markedly distended bladder are apt to be mistaken for ascites. In ovarian tumor, however, the dullness is central and remains more or less fixed as the patient changes his position, while in ascites, as has just been mentioned, the dullness is in the flanks while the patient is lying upon his back and shifts as the patient moves. The umbilicus is flat or bulging in ascites, while in ovarian tumor it is drawn upward. A dullness due to a distended bladder is, of course, readily cleared up by emptying the bladder. Tumors will give a dull note

and the points to be considered in arriving at an opinion concerning them has already been mentioned and discussed while considering palpation of the abdomen.

Before leaving the subject of percussion of the abdomen it will be well to call attention to a sign whose chief value lies mostly in its reputation and not its real worth, the so-called *hydatid thrill*. This is elicited by placing several fingers over the suspected cyst and percussing one finger, when a thrill will be felt with the other fingers. The sign is by no means constant. The usual percentage stated is fifty positive. Personally I have never seen it elicited.

Auscultation.—The practice of auscultation like that of percussion may be either direct or indirect, if one may be allowed these terms. By direct, referring to the placing of the ear against the chest; and by indirect the use of some instrument or medium to collect the sounds and transmit them to the ear. There are occasions when use of the ear alone is desirable and for this reason and the additional one that one may be caught without a stethoscope at times, every one should train himself to use the unaided ear. The use of the stethoscope will be described elsewhere with a careful description of the instrument and the physical laws involved. Suffice it to say here the stethoscope must be used with an intelligent appreciation of its limitations as well as of its advantages.

*Lungs.*—In auscultating the lungs there are three points of information desirable: (1) Character of breath sounds (2) character of voice sounds, (3) presence and character of any abnormal sounds.

The patient should be in an easy position and without constraint, with all parts readily accessible if able to sit up. If confined to bed he can be rolled from one side to the other and in no case should a very careful examination of the back and bases be omitted, especially in a bed-confined patient. The examination should not be too prolonged. The subject should breathe through his nose regularly and fairly deeply, but not noisily. Later he should be made to cough, the breath sounds being noted after coughing. The two normal breath sounds heard in every chest should be carefully and thoroughly studied. The first is vesicular breathing and the second bronchial breathing. The first is heard all over the alveoli and the second over the trachea and larger bronchi. In the smaller bronchi there exists a mixture of these partaking exclusively neither of the soft murmur heard in vesicular breathing nor of the more or less pronounced blowing sound heard in bronchial breathing, but as stated by a mixture of the two, known as bronchovesicular. This becomes of significance in certain pathological conditions where it occurs elsewhere than over the smaller bronchi. Vesicular breathing can be heard most typically in the axillary and infrascapular regions and consists of a fairly intense constant low-pitched rustling or murmur. The inspiratory and expiratory sounds follow each other normally without any distinct pause, the inspiratory being of a more intense and higher-pitched quality and usually, under normal conditions, is heard for at least twice as long as the expiratory.

The sound heard over the trachea best teaches the quality of bronchial breathing, though it is more intense and exaggerated than normal bronchial sounds. The pitch is higher than that of the vesicular and instead of a murmur is a more distinct blowing. In bronchial breathing the expiratory sound is more intense, of higher pitch; as long as or longer than the inspiratory and is divided from the inspiratory by a distinct pause.

Vesicular breathing is divisible into: (1) Puerile, (2) harsh, (3) jerky, interrupted, or cogwheel, (4) feeble.

The first or puerile variety consists merely of a more intense quality and the sounds are more harsh but of the same duration. This is the type of breath-sounds heard in infants and small children.

In harsh respiration the character is as the name implies, but in addition there is a prolonged expiration; the character, however, does not become blowing. This kind of breathing is found in lungs with a diminished elasticity, for instance, in pulmonary tuberculosis and certain types of bronchitis.

The character of jerky or cogwheel respiration is also well described by its name and is as one would suppose not a continuous sound but occurs in jerks. It is indicative of unequal or irregular expansion of the alveoli due to unequal elasticity and so is found in the same conditions as number two. It should not be described with too much importance, however, as it is often the result of simple nervousness.

Feeble respiration is the one most apt to lead to error, as often in normal breathing the expiratory sounds are inaudible and frequently in the bases breath sounds are difficult to elicit. When unable with deep breathing to obtain the sounds one may interpret the condition as due to poor expansile ability.

The sounds totally disappear below the level of pleuritic fluids, this being usually due to the very poor conductivity of the relaxed lung tissue. There are occasional instances of pleuritic exudation with increased sounds. This occurs with large accumulations of fluids, and the sounds in this instance will possess a marked bronchial character.

The expiratory sound is at times unduly prolonged and occurs in such conditions as asthma, early tuberculosis, and emphysema.

Bronchial breathing, like vesicular, is divisible into three varieties: high pitched, medium, and low pitched. We find low pitched in the larger tubes normally, pathologically over lung cavities where it assumes a cavernous quality. High pitched is the usual variety meant when we speak of bronchial or tubular breathing and is heard in pneumonia best, where consolidation has occurred in the region of and around the medium sized and smaller tubes. Medium pitched bronchial breathing is a grade found between these other two. Amphoric breathing, already spoken of, is a variety of bronchial breathing and resembles very closely the sound produced by blowing across the mouth of a bottle. It is significant of a direct communication between a bronchus and a cavity or a bronchus and pneumothorax.

Bronchovesicular breathing occurs when one is able to hear below a thin layer of alveoli the sounds in a bronchus. Here one gets an admixture of the two different elements, one or the other type predominating dependent upon the relative amount of tissues. It occurs normally near the root of the lump behind and near the midline in front over the upper portions. It occurs pathologically in consolidations when the area of solidified lung tissue does not quite reach the surface.

*Vocal Resonance.*—It must first be borne in mind that normally there is heard with different intensity on the two sides of the chest the buzzing sound produced by articulation as described above, that on the right side being louder; also over a large bronchi the sound is more intense. When the sounds are so close as to be almost a vibration in the ear itself the condition is spoken of as bronchophony and when words spoken are clearly heard it is pectoriloquy. Increased fremitus occurs in consolidations. Bronchophony occurs when a bronchus of any size is surrounded by solidified lung tissue all the way to the chest wall. Pectoriloquy occurs when a cavity communicates with a bronchus. It also occurs in certain cases of effusion compressing parts of the lungs, above the level of the effusion. Below the level of the effusion vocal resonance is, of course, entirely absent. It is diminished in cases of emphysema (at times absent) and in thickened pleura.

In addition to accentuation or diminution of the

EXPLANATION OF
PLATE XXXI

## EXPLANATION OF PLATE XXXI.

(In all the figures the blue color indicates the superficial, and the red color the deep, cardiac dulness. The shaded wedges show the area over which the murmurs are heard, and indicate by their thickness the intensity of the sound.)

FIG. 1.—Mitral Insufficiency. Showing slight hypertrophy of the left ventricle, and marked hypertrophy of the right side of the heart. Accentuation of pulmonic second sound, indicated by the sign ⊥∪ at the base. Murmur heard at apex with maximum intensity, transmitted to the left (>) and diminishing.

FIG. 2.—Mitral Stenosis. Left ventricle of normal size. Hypertrophy of left auricle and of right side of heart. Pulmonic second sound accentuated; maximum intensity within apex: murmur increasing to first sound (<); not transmitted.

FIG. 3.—Aortic Insufficiency. Left ventricle greatly hypertrophied. Right side of heart normal in size. Murmur heard over a considerable area, at times with maximum intensity at base in aortic area, at times at lower end of sternum. No accentuation of second sounds.

FIG. 4.—Aortic Stenosis. Left ventricle somewhat hypertrophied. No changes on right side of heart. Murmur heard with maximum intensity in the aortic area, transmitted up into the cervical vessels.

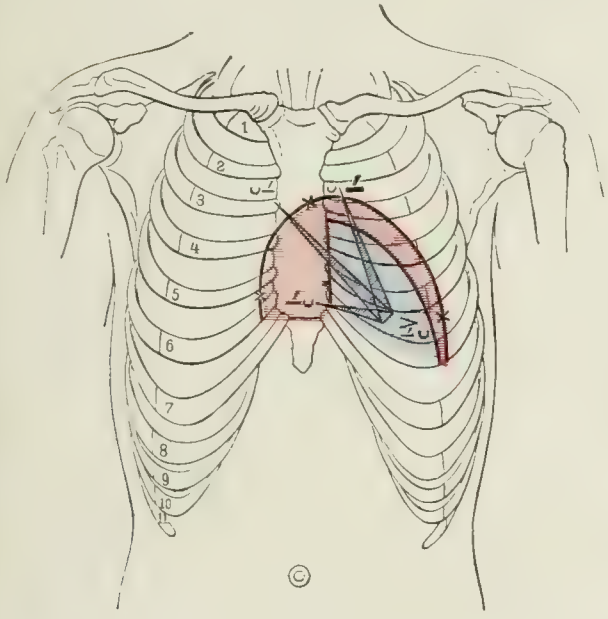

Fig. 1.

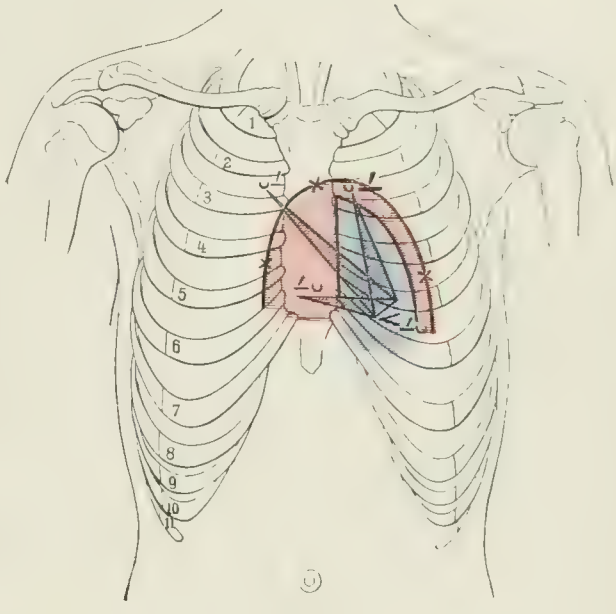

Fig. 2.

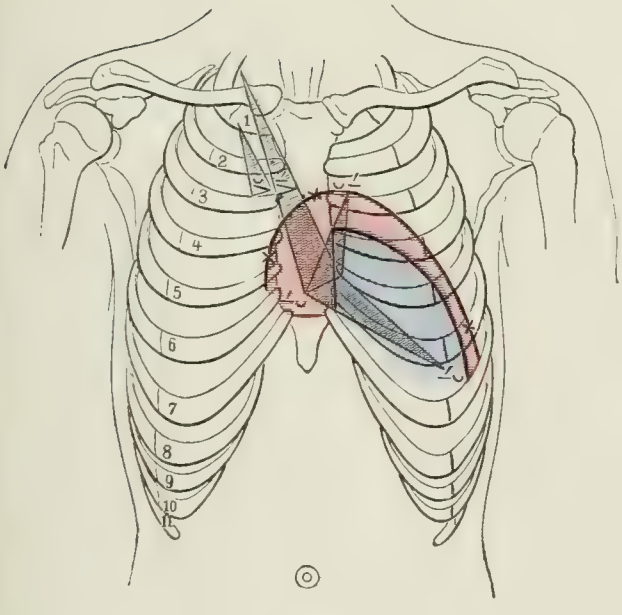

Fig. 3.

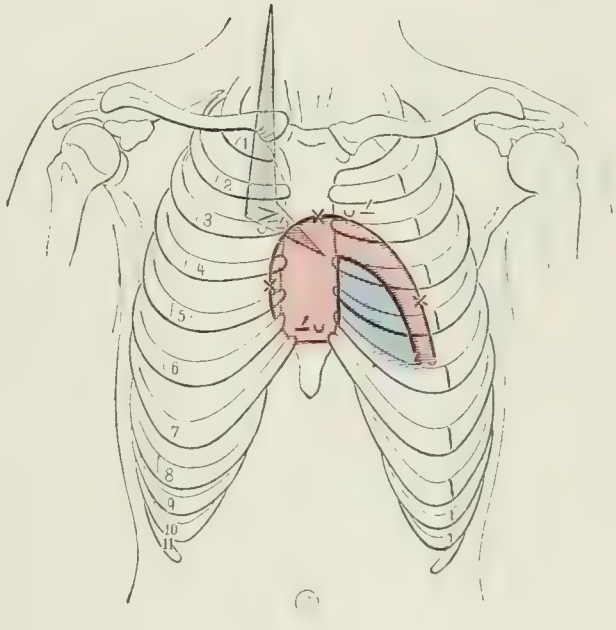

Fig. 4.

## GRAPHIC REPRESENTATION OF THE PHYSICAL SIGNS FOUND IN THE FOUR MOST COMMON VALVULAR LESIONS OF THE HEART

From Sahli's "Lehrbuch der klinischen Untersuchungs Methoden," etc

voice sounds we recognize changes in the character or quality of the sounds. Pectoriloquy is one of these changes.

*Amphoric or metallic* resonance is another change and occurs in pneumothorax. We also have nasal or bleating voice sounds. This is a peculiar nasal intonation as if the person were talking through the nose, and occurs in cases of pleurisy with small effusion which separates the lung from the chest wall by a thin layer of fluid and is known as egophony. It is probably due to collapse of bronchial tubes.

*Râles and Crepitations.*—We may divide these into dry râles and moist râles. Dry may be sibilant or high pitched, medium pitched, sonorous, or low pitched. Moist râles or crepitations may be non-resonant or resonant. The non-resonant are fine, medium, or coarse. The resonant are never fine, they are either medium or coarse.

The dry râles are produced in the air passage by swelling of the mucosa or blocking of the lumen by tough secretions. The moist râles arise either in the alveoli or bronchioles. They produce a noise like the bursting of air bubbles and are indicative of fluid secretions in the alveoli or bronchioles. The dry râles are sibilant or high pitched over the smaller tubes and are most abundant during the end of inspiration. The medium-sized tubes give medium-pitched râles and large tubes sonorous or high-pitched râles. These latter are heard early in inspiration. Dry sounds characterize bronchitis and other respiratory disease where the bronchi become partially filled. The moist râles as stated above are fine, medium, or coarse, the coarse being often spoken of as bubbling. Fine crepitations are caused by the sudden expansion of the alveoli whose walls are stuck together with exudation. This separation, as the adhesions give way, is accompanied by a fine cracking sound best imitated by rolling between the fingers in the neighborhood of the ear a lock of hair. They occur near the end of inspiration and are characteristic of acute congestion. They are heard in the first stages of pneumonia, early in tuberculosis, in edema of the lung, and occasionally after atelectasis. Medium moist râles occur in the smaller bronchi and are heard at the end of inspiration and beginning of expiration. They are caused by air bubbling through fluid secretions contained in the lumen of the tube. Coarse moist râles occur as one would suppose over the large tubes and may be heard at any time during respiration, or at all times. They occur also in cavities. The now resonant moist râles occur in spongy lung tissue. The highest degree of resonance is the metallic or tinkling resonance. Here a definite pitch occurs and as it has been aptly described gives the impression of a continuous dropping of fluid into a metallic vessel. This is associated with amphoric breathing and is characteristic of a cavity or pneumothorax.

The location of the râles has a direct influence upon the importance to be attached to them. In case of fine râles at the apex we think of pulmonary tuberculosis; while medium and coarse râles at the base may be due to a simple exudation, as seen in bed-ridden patients lying too much upon the back, and readily disappear.

*Friction sounds* possess a creaking, rubbing character. They may be fine, coarse, or medium. At times, when fine, a friction sound is rather hard to distinguish from a râle, but differs in the time of its occurrence as related to the respiratory cycle. The friction sounds occur during both inspiration and expiration at the time when the roughened pleural surfaces are rubbing against each other. They are unchanged by coughing; while râles will change in nature because of a change in disposition or position of fluids causing the râles. Friction sounds are at times more localized than râles. Friction may be intensified by firm pressure with the stethoscope, râles never.

Pleuropericardial friction is a friction sound developed in the lung where it overlies the heart, and is synchronous with the heart beat. It has been described and its differentiation both from heart sounds and pleural sounds given in another place.

*Cardiac Area.*—It is well for one to train himself in the technique of both the direct and indirect methods of auscultation in this area, for there are points of information to be derived by each method. In the direct, one will, in addition to obtaining information regarding the clearness and intensity of the sound, note also the impulse and other tactile sensations and will be able to gauge more accurately the time in the cardiac cycle at which some given sound occurs. On the other hand with a stethoscope one can limit his field of observation to a single area. This is a very important point in studying the intensity of both normal and abnormal sounds and the direction of transmission of adventitious sounds. As there will be found in the article on *Cardiac Murmurs* a discussion of the heart sounds, both normal and abnormal, and as this discussion goes fully into their characteristics and causations, there will here be made mention only of the various valve areas. In this connection the reader's attention is called to Plate XXX which shows the auscultatory phenomena of four of the most common heart lesions. Especially are to be noted the points of accentuation and reduplication of sounds and the transmission of murmurs.

In auscultating the cardiac area the first and second heart sounds are heard with varying intensity and clearness at different points, and it is possible to appreciate the sounds made at the different valves. The area at which, or the point at which the valve sounds are best heard are called the valve areas. These points do not correspond anatomically with the situation of the valve but are the points to which the vibrations set up at the particular valve are transmitted with the greatest intensity. There are four and they are named according to the valve from which the sound proceeds: aortic, pulmonary, tricuspid, and mitral. The four valves themselves are situated nearly in the midline, one just below the other; and beginning with the pulmonic at the junction of the third rib with the sternum on the left they run downward and inward until the tricuspid is situated nearly behind the middle on the sternum opposite the junction of the fifth rib. The areas to which they transmit their vibrations occupy very different locations as will shortly be defined, and these vibrations are transmitted in the case of the mitral and tricuspid valves through the chordæ tendinæ and papillary muscles and in the aortic area through the walls of the aorta.

The *Mitral Area* is usually spoken of as the apex or point of maximum cardiac impulse. It is situated normally in the sixth interspace to the left of the sternum in the left nipple line.

The *Tricuspid Area* is situated at the lower end of the sternum. At times the tricuspid sounds are best heard just to the left of the lower end of the sternum.

The *Aortic Area* is situated in the second right intercostal space close to the sternum. The second right cartilage is often called the aortic cartilage.

The *Pulmonic Area* is in the second intercostal space to the left close to the sternum and is thus just above its valve, corresponding more closely than any of the others with the true anatomical situation of the valve.

*Abdomen.*—Auscultation of the abdomen probably is productive of less information than any other procedure employed. In the stomach region one may listen for the swallowing, bubbling, and splashing sounds and for abnormal heart sounds. One may hear friction sounds from peritoneal adhesions; bruits over an aneurysm; fetal heart sounds over a pregnant uterus and gurglings over the intestines from passage of gases and fluids through the valves and constricted portions of the intestines. The

bubbling sounds will usually be due to fermentation. The splashing sound is of no diagnostic importance unless heard some time after a meal, three to four hours at the earliest; and when heard this long after a meal and below the umbilicus it is a very valuable sign of dilatation. The swallowing sounds may possess some slight diagnostic value when unduly delayed. That is, in having a patient swallow water and listen over Traube's space for the opening at the cardiac end. It may direct attention to some esophageal condition or to cardiospasm. Auscultation over the spleen will show a friction rub in perisplenitis and in splenic infarcts.

Auscultation over the intestines will show as mentioned above gurglings and splashings and at times a general ill-defined murmur of a very low pitch due to movement of the intestines. In a pregnant uterus will be heard in addition to the fetal heart sounds, the placental souffle. HOUSTON B. HIATT.

**Diamino acids** include such substances as lysine ($\alpha$, $\varepsilon$, diamino-caproic acid) and histidine (guanidine $\alpha$-amino-valeric acid) products of decomposition of the protein molecule containing two amino groups. On putrefaction they give rise to cadaverine and putrescine respectively. FRANK P. UNDERHILL.

**Diamines.**—See *Cadaverine, Putrescine, Ptomaines.*

**Diaminuria.**—This is the presence of diamines in the urine. A diamine is an amine derived from a double molecule of ammonia, the atom of hydrogen being replaced by hydrocarbon radicals. Diaminuria has been attributed to defective processes of the body, and has been observed practically only in connection with cystinuria. Cystin is the disulphide of amido-ethylidene lactic acid. In a number of instances cystin has been reported in cases in which the diamines were absent at the time of the examination. The excretion of the diamines does not always go hand in hand with the excretion of cystin, indicating the possibility that the two substances do not depend absolutely upon the same cause.

Certain diamines, especially cadaverine, putrescine, and a third diamine probably identical with saprine or neuridine, formerly regarded as evidences of the action of certain bacteria upon albuminous material, probably can be produced within the body without the intervention of microorganisms. Their presence is now regarded as evidence of defective oxidation processes in the body.

Cadaverine and putrescine were originally discovered by Brieger in putrifying cadavers, and later were found also in cultures of the spirillum of Asiatic cholera, the Finkler-Prior vibrio of cholerine, the bacillus of tetanus, and in the ricewater stools of cholera. The three diamines mentioned above (cadaverine, putrescine, and the diamine probably identical with saprine or neuridine) were first found in the urine in a case of cystinuria, by Baumann and Udranszky. Baumann believed that the formation of diamines in the urine is in some way responsible for the cystinuria, and inferred that the cystinuria is essentially an infectious disease of the intestinal canal. This opinion and inference have not been confirmed. On the other hand, it has been shown that the diamines may be formed in the absence of microorganisms.

Putrescine, tetramethylenediamine, may be formed in the laboratory by the reduction of alkylon dicyanides or nitriles with metallic sodium and absolute alcohol:

$$\begin{array}{lll} \mathrm{CN} & \mathrm{CH_2NH_2} & \mathrm{CH_2.CN} \\ +8\mathrm{H} = & | \quad ; & | \quad 4\mathrm{H_2} = \\ \mathrm{CN} & \mathrm{CH_2.NH_2} & \mathrm{CH_2.CN} \end{array} \qquad \begin{array}{l} \mathrm{CH_2.CH_2.NH_2} \\ | \\ \mathrm{CH_2.CH_2.NH_2} \end{array}$$

Dicyanogen — Ethylene Diamine — Ethylene Cyanide — Tetramethylene-diamine or Putrescine.

Cadaverine which is chemically pentamethylenediamine, $\mathrm{CH_2}\begin{array}{l}\diagup \mathrm{CH_2.CH_2.NH_2} \\ \diagdown \mathrm{CH_2.CH_2.NH_2}\end{array}$, may be obtained by the reduction of trimethylene cyanide, much the same as putrescine is obtained from ethylene cyanide in the above illustration.

*Diagnosis.*—The following is the method of examination of the urine for diamines, according to Baumann and v. Udranszky. To the twenty-four hours' urine there are added a ten per cent. solution sodium hydrate and benzoyl chloride in the proportion of 1500 : 200 : 25, and the mixture is shaken until the odor of benzoyl chloride disappears. The precipitate, containing phosphates, benzoyl compounds of the carbohydrates of the urine, and some of the benzoylated diamines, is filtered off under suction and digested with alcohol. Concentrate to a small volume and add about thirty volumes of water. Within twelve to twenty-four hours, the benzoylated diamines form a milky sediment composed of fine white crystals. The benzoylated carbohydrates are removed by dissolving the precipitate in alcohol, concentrating, and diluting with water. This process may be repeated several times. The diamine crystals part with their water of crystallization at 120° C. and melt at 140° C. The benzoyl diamines in the first filtrate may be recovered by acidifying with sulphuric acid and extracting with ether, the ethereal residue, before congealing, being placed in four or five times as much twelve per cent. sodium hydrate solution as is required for neutralization. In the cold, long needles and platelets separate out, consisting of benzoyl cystin and benzoylated diamines. The filtered sediment is placed in cold water, which dissolves the sodium benzoyl cystin and leaves the benzoyl diamine.

To separate the putrescine from the cadaverine, dissolve the crystals in warm alcohol and add twenty volumes of ether. The precipitate of benzoyl putrescine melts at 175° to 176° C., and the melting point of the benzoyl cadaverine, contained in the ethereal residue, is 129° to 130° C.

Separation of the diamine from the benzoyl radical is accomplished by heating the crystals on a water bath with equal parts of alcohol and concentrated hydrochloric acid for twelve to twenty-four hours, until a specimen is entirely dissolved by sodium hydrate, then dilute with water and filter off the benzoic acid, extract the residue with ether to remove remnants of benzoic acid, and evaporate to dryness. The residue consists of putrescine- and cadaverine-hydrochlorate. The platinum salt is formed by adding an alcoholic solution of the residue to an alcoholic solution of platinum chloride, and the resulting crystalline mass may be purified by recrystallization from hot water. The addition of sulphuretted hydrogen will decompose this salt to form again the hydrochlorate. Upon distilling the hydrochlorate with caustic potash, the free base passes over as a colorless liquid when the temperature exceeds 160° C., the boiling point of the base being 173° C. The odor of the base is described as sperm-like, and it readily combines with the carbon dioxide of the air to form the carbonate. GEORGE E. MALSBARY.

**Diapedesis.**—By this word (the accent of which should be on the syllable next to the last) is meant the passage "of blood or any of its formed elements, especially the leucocytes, through the unruptured walls of the blood-vessels." It is made from the Greek word meaning I leap through, and the suggestion of this etymology agrees very closely with its frequent limitation to the ready passing of the ameboid leucocytes between the jagged endothelial plates which, placed edge to edge, wholly make up the blood capillaries.

Launois claims that Dutrochet first described

diapedesis in 1824, Walter discussed it in 1846, Stricker in 1865; Thomas Recklinghausen demonstrated that the passing of the leucocytes is an active process, a true action; while Conheim in 1867 showed that the leucocytes can creep, by ameboid movement, also through the wall of the normal veinlet.

The functions and nature of the capillaries have generally been more or less misconstrued if my own notion be correct that almost their sole function, so far known, at least, is to prevent the countless myriads of erythrocytes (red corpuscles) flowing through them from getting lost and therefore useless in the tissue cell spaces, where being wholly passive bodies, unlike the leucocytes, they would be mischievous cloggers of the nutrient and respiratory lymph flow through the tissues. So far as we know, certainly, aside from this direction and restraint of the stream of reds and the other components of the whole blood into the veinlets, the *capillaries are practically as if they were not there at all*, so very thin and permeable and delicate are their walls, and so readily are the endothelial cells composing these walls strained apart either by the insinuating pseudopod of a leucocyte or, perhaps, by the mob-violence, so to say, of a local plethora or an inflammatory leucocytosis of a sharply localized nature. These essential considerations become obvious almost when the extreme thinness of the capillary wall is remembered—ordinarily much less than the thousandth of a millimeter, or say a quarter of the little thickness of a red corpuscle. The capillaries are, properly speaking, the most essential, primary, part of the circulation and to minister to their functioning all the other elaborate mechanism of heart and its nerves, arteries, and veins exists—this function is to supply freely the blood, minus its erythrocytes, to the tissues. Sihler's claim, of much interest in this direction, that a plexus of neurofibrils everywhere surrounds the capillaries, has apparently never been corroborated; and we seem, in fact, to have no data from which to suppose that the capillary epithelium has special osmotic or secretory powers which make it able to determine adaptations to changing requirements in and about the capillaries.

Such being probably the case, it seems necesssary to conclude that diapedesis of the red corpuscles is accidental and unphysiological, although harmless if it occurs; that the blood plasma and lymph osmose (or filter?) back and forth with extreme readiness; and that the leucocytes actively ameboidize (if the verb may be coined?) in great numbers outward and inward between the endothelial plates of the capillary and veinlet walls, the former, or outward, direction being rendered especially easy and convenient by the fact that the white corpuscles move and roll along in the capillary close to its wall (the so-called cycloid movement).

Renaut suggests two particular functions for diapedesis: oxidation and glandular secretion. We know how important the leucocytes are in villous absorption; but it is as scavengers, or police officers bent on arresting (and devouring!) dangerous disturbers of the metabolic peace that they seem to perform their most important duty (Metchnikoff).

We may well agree with the remarks of Pohlman, in the second edition of this HANDBOOK, on this matter in relation to inflammation: "It is misleading to speak about physiological and pathological diapedesis. The latter represents merely an accelerated activity of the former; they differ from each other in quantity, but not in quality. In physiological conditions the white cells travel constantly from blood and lymph vessels into the surrounding tissues, but the work of these wandering cells is practically unknown, and what little we know is confined to the alimentary tract, where they aid in carrying fat globules into the circulation, traveling backward and forward until the work is done. Diapedesis becomes more active in many of those conditions which are not quite physiological nor quite pathological, such as the smoothing of sharp bony edges or the absorption of different forms of 'lumps.' Its activity increases rapidly when pathological conditions arise. In the repair of those wounds which we say 'heal by first intention,' the white cells leave the blood-vessels in large numbers, and aid, first, in the coagulation of the blood which unites the edges of the wound; after that they fill the wound completely, and while some provide the necessary nutriment for the connective tissue which is forming, the others find their way back again into the circulation by way of the lymphatics when their services are no longer required. When, however, bacteria or irritants have entered the wound, diapedesis assumes its most intense form. Masses of white corpuscles leave the vessels and, entering the tissues which surround the infection, they pack themselves so close together that they almost form a membrane which separates the healthy from the unhealthy tissues and prevents the infection from spreading. The white corpuscles which die in this struggle are found in the wound as pus corpuscles."

GEORGE V. N. DEARBORN.

**Diaphoretics.**—This is a class of remedies which promote the action of the sudoriparous glands. *Sudorifics* is a synonymous term. The free action of these glands we know to be a most important function of the skin. An abundant secretion means general comfort. The temperature of the body is influenced according as the perspiration is increased or diminished; when it is profuse the evaporation from the surface abstracts a larger amount of body heat and thus follows a fall of body temperature. This action of the skin also forms an efficient emunctory, removing from the blood much effete and toxic matter, whether formed within the body or introduced from without. Nature adopts this means of relief in the profuse sweatings of hectic and other fevers, and all are familiar with the relief that follows the appearance of a moist skin in febrile conditions.

The action of the sudoriparous glands is directly under the control of the nerve supply, but is indirectly influenced by the conditions of the cutaneous vessels and the free or impeded circulation. In all forms of pyrexia there is increased tension and turgescence of the cutaneous vessels with diminished circulation, and lessened secretion of the glands. With a relaxation of this tension and freer flow of blood, there at once follows an increased action of the skin.

In considering diaphoresis it is necessary to remember that recourse is had to it in both pyretic and apyretic states. Under the first condition the normal action of the skin has been checked and we endeavor to restore this function, while in apyrexia our efforts are directed to increasing the action of normally acting glands. In the selection of diaphoretics we find that they arrange themselves in two groups according to the action expected. When there is fever the best diaphoretics are those which dilate the peripheral vessels and have a depressant effect upon the heart and circulation; of these aconite, antimony, and ipecac are the best known. Diaphoretics of this class are of service in all fevers to reduce temperature and in all threatened inflammations of deep organs, as bronchitis, tonsillitis, etc., to avert or lessen the severity of the attack. In apyrexial states we resort to drugs which act directly upon the glands and stimulate their action. The drug employed is pilocarpus, which is used to remove edema of the tissues and dropsies, and also in anemic troubles, to remove from the blood much of the toxic material present. It is also recommended in many forms of slow acting poisons, as opium and belladonna, to hasten their elimination from the blood. Pilocarpus also combines with this direct action on the glands a

depressing effect on the vascular system, which makes it serviceable in pyrexias; so also many of the diaphoretics which are most useful in fevers exert an influence upon the glands, such as spirit of nitrous ether, acetate and citrate of potassium.

*Aconite* is one of the most valuable diaphoretic drugs that we possess. It acts rapidly and its effect is readily controlled. When the skin is dry, the pulse hard and rapid, a few doses will, generally within an hour, produce a moist skin and soft, slow pulse. It must be used carefully, particularly in debilitated patients, in advanced inflammatory diseases, on account of its depressing action on the heart and circulation. The tincture is usually selected for administration in doses of one to five minims every two or three hours. The best effect, however, is attained by following the method recommended by Ringer and give one-half to one minim every ten or fifteen minutes for two hours and then every hour if necessary. It should be discontinued as soon as the pulse is slowed.

*Antimony*, as the wine or in James' powder, or combined with opium, was formerly a favorite diaphoretic in the treatment of fevers, but is now never employed. Its great depressant effect which persisted for a long time, and the gastric disturbance it caused, led to its disuse.

*Ipecacuanha* is a diaphoretic which is much used, but it cannot be employed for any length of time on account of the nausea it produces. The wine is generally selected in doses of ten to thirty minims, or the syrup thirty to sixty minims.

*Spirit of nitrous ether* forms one of the most satisfactory remedies of this class. Its action is rapid. Its depressant effect is very slight, its action being directed upon the secreting glands as well as upon the vascular system. Its effect is allied to amyl nitrite and other nitrites. It may be administered freely and to the youngest infant. The dose for infants is from one to five minims, and for adults from thirty to sixty minims, repeated every half hour until the desired effect is secured.

*Liquor Ammonii Acetatis* possesses mild diaphoretic action. It is free from any ill effects and may be given freely. It acts best in combination with aconite and sweet spirit of niter. It is given in doses of four to eight drams.

*Phenacetin*, *Antifebrin*, and allied drugs possess diaphoretic action and may be used with satisfaction in doses of three to five grains every two or three hours. Their depressant action, however, is very marked in some patients and they require to be used with caution.

*Pilocarpus* is the most powerful and effective diaphoretic we possess. Its activity is its one drawback, as it also exerts an influence on the salivary glands and mucous membranes of the bronchi, causing a very free and dangerous secretion in these parts. Its effect also persists and may be uncontrollable, with blocking of the bronchial tubes and danger of pulmonary edema. When there is no fever its action is principally directed to the surface of the body. The most profuse secretion will follow its use when combined with the hot pack, which lessens the effect of the drug on the salivary glands and the bronchial secretions.

Its alkaloid *pilocarpine* possesses all the virtues of the drug and is administered in doses of one-eighth to one-half grain hypodermically.

The effect of individual diaphoretics is increased by combination with one another, aconite or ipecac with liquor ammonii acetatis and spirit of nitrous ether is more rapid and produces a more free diaphoresis. Ipecac with opium in the form of Dover's powder is one of the most effective diaphoretics we possess in doses of ten grains at bedtime. When combined with hot drinks they also become more effective, and where free diaphoresis is desired hot drinks should be administered freely. Alcohol given in this way promotes the cutaneous circulation and favors diaphoresis.

Heat to the surface of the body is also most valuable as an adjunct to all diaphoretics, and should always be combined with their administration. Hot sponging, pediluvia, hot water or steam baths, and hot packs may be employed according to the severity of the condition and the effect desired.

BEAUMONT SMALL.

**Diaphragm.**—The dome-like, musculotendinous septum that in man and other mammals separates the cavity of the thorax from that of the abdomen has received this general name (from Gr. διάφραγμα, a partition wall), an appellation sometimes used for other partitions, as the floor of the mouth or of the pelvis, the membrana tympani, etc. Laurentiur (1558–1609) appears to have been the first to use the term. The older writers called it φρήν, hence our term phrenic. As emotions of the mind are manifested by agitation of the diaphragm, φρήν was soon used to signify the mind itself. Celsus and Vesalius called it the *septum transversum*. The older appellation for it in English was *midriff*, which like the German *Zwerchfell* implies a transverse septum.

Its importance in respiration and circulation of the blood was early recognized, and Spigelius said of it: "*Musculus unus sane omnium fama celeberrimus;*" and Haller calls it: "*Post cor facile princeps.*"

In man it appears as an enormous leaf, of which the divided stem, called the crura or pillars, is attached to the spinal column, while the blade is a musculotendinous sheet that arches over the abdominal viscera from behind upward and forward, and is attached by its serrated edge around the entire lower circumference of the thoracic cage.

The septum which in fishes separates the cavity of the branchiæ from the abdomen appears to be a rudimentary form of this muscle. In birds it is represented by muscular slips that pass up from the lower ribs to be inserted upon the pleural sacs. Only in mammals is a complete septum formed, and its shape in the different groups is largely influenced by the length of the sternum and the number of the ribs. In whales the sternum is very short and the diaphragm is almost dorsal to the abdominal cavity, so that Daubenton and Cuvier supposed it to be a direct continuation of the transversalis abdominis. In most mammals the arch is more pronounced than in man as the ribs approach nearer the pelvis.

Embryological studies show that the diaphragm, like the heart, develops in what is to be the upper part of the neck. It is apparently derived from the third to the fifth cervical myotomes. During the growth of the body causing the so-called "descent" of the heart the diaphragm is carried, together with that organ, into the thorax, but maintains, through the cervical fascia, its primitive connection with the neck and extends downward along the lumbar vertebræ. From its derivation it is classed with the system to which the rectus abdominis belongs, represented in the neck by the infrahyoid muscles. It is early divided into two portions, one ventral, associated with the *septum transversum* of His, a mesoblastic fold raised by the growth of the liver, another dorsal, forming sheets of fascia that enfold the heart and constitute the pericardium, working out laterally to complete the septum and finally uniting with the ventral portion. Probably the union takes place later on the left than on the right, as diaphragmatic hernia is much more frequent on that side. It is really a bilateral muscle, but the two antimeres are so closely united that it appears to be single.

DIVISIONS.—We may distinguish in the diaphragm the following portions: (1) A central, *aponeurotic area* usually destitute of muscular fibers and known as

the *central tendon*. (2) A *lumbar portion*, composed of the muscular fibers constituting the *crura*. (3) A *costal portion*, inserted upon the cartilages of the lower six ribs. (4) A *sternal portion*, inserted upon the xiphoid process.

Attachments.—It is usually stated that the diaphragm has its origin from the lower border of the thorax and from the spine and is inserted into the central tendon. If, however, we consider the most fixed portion of the muscle as its origin, this is inaccurate. The central tendon, held in position by strong bands that blend with the pericardium and are known as the phrenopericardiac, sternopericardiac, and vertebropericardiac ligaments, has but little movement (not more than one centimeter, Hasse) and it is from this fixed point that the muscle acts. This was first recognized by Teutleben who called the pericardiac ligaments the *Ligamenta suspensoria diaphragmatis*. Forbes afterward named them the superior tendinous crura of the diaphragm. A more accurate statement of the origin and insertion of the muscle is as follows:

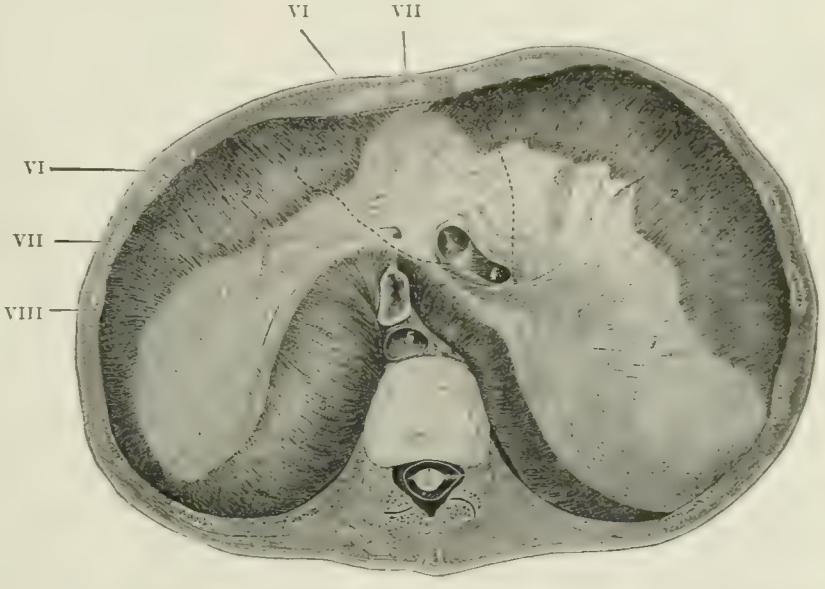


Fig. 1663.—Diaphragm; Convex Surface. 1, Central tendon; 2, pars costalis; 3, pars lumbalis; 4, vena cava inferior; 5, aorta, with the esophagus adjacent. VI.–VIII., ribs. (After Eisler.)

Origin.—1. By pillars or crura from the lumbar spine. 2. By the pericardiac ligaments extending from the central tendon over the pericardium to the sternum and to the prevertebral layer of cervical fascia. 3. By the three arcuate ligaments or tendinous arches, extending from the spine to the tip of the last rib.

Insertion.—1. On the six lower costal arches. 2. On the xiphoid process of the sternum by two fascicles.

The central tendon (*centrum tendineum*, BNA) is formed of glistening white, closely interwoven bundles of connective tissue. The peculiar, metallic luster of its caudal surface when perfectly fresh led van Helmont to ascribe to it special reflecting functions, and it is sometimes called the *speculum Helmontii*, van Helmont's mirror. It varies in shape, extent and character in different animals, being sometimes practically wanting, that is to say replaced by muscular tissue, as in porpoises and whales, sometimes having a tendency to ossify as in the dromedary, llama, and hedgehog. In man it has the shape of a trefoil leaf, of which the three leaflets or folioles vary in size, the middle or ventral leaflet being the smallest, and the left one next in size. As compared with the muscular part it is proportionally somewhat smaller in children and larger in old age. It is continuous above with the fibrous layer of the pericardium, and when the diaphragm contracts the pericardial cone becomes tense and prevents the expanding lungs from pressing upon the heart.

The lumbar portion (*pars lumbalis*, BNA) has often been described as consisting of two crura, or pillars, right and left, arising from the bodies of the lumbar vertebræ. Under the nomenclature prescribed by the BNA this is considerably modified. On each side *three* crura are described, the medial crus arising by a flattened tendon from the bodies of the first four lumbar vertebræ (on the left the first three) and their associated discs, blending with the anterior common ligament of the spine. Soon becoming muscular it arches, at the level of the first lumbar vertebra across to the opposite side, forming a tendinous band, the middle arcuate ligament, in front of the aorta and the thoracic duct. The orifice thus formed is the aortic opening (*hiatus aorticus*, BNA). In front of this opening the crural fibers again decussate to surround like a sphincter the lower portion of the esophagus, forming the esophageal opening (*hiatus œsophageus*, BNA). They are then inserted into the central tendon.

At the lateral side of this medial crus is a second pillar (*crus intermedium*, BNA, often called the accessory pillar) incompletely separated from the medial pillar by the greater and lesser splanchnic nerves.

A third pillar (*crus laterale*, BNA) is considered to be formed by the fibers that spring from two tendinous arches, the first of which (*arcus lumbocostalis medialis*, BNA,* psoas arcade, internal arcuate ligament) extends from the body of the second lumbar vertebra over the psoas magnus muscle to the ventral surface of the transverse process of the same vertebra, often sending also an intermediate strand to the tip of the transverse process of the first lumbar vertebra. It is considered as a thickened band of the iliac fascia. The second arch (*arcus lumbocostalis lateralis*, BNA,* quadratus arcade, external arcuate ligament, *ligament cintré* of Cruveilhier and other French anatomists) stretches from the tip of the transverse process of the first lumbar vertebra over the quadratus lumborum to the cranial aspect of the twelfth rib. It appears to be a thickened portion of the transversalis fascia, or it may be considered as a dependence of the lumbocostal ligament, and thus related to the lumbar fascia.

The muscular fibers constituting this lateral pillar may be absent, leaving a gap known as the costolumbar hiatus (*trigonum lumbocostale*, Rauber-Kopsch). This is more frequent on the left side, and is probably caused by defective development leading to lack of union between two portions of the muscle

* The designation "Halleri" attached to these appellations in the BNA is erroneous. The arches were first described by Senac in 1729, as mentioned by Haller himself.

primitively distinct. Such a defect may lead to a diaphragmatic hernia.

The costal portion (*pars costalis*, BNA) comprises those parts that are inserted by short tendons, extending in a slightly curved line, convex downward, on the internal face and cranial edge of the six lower ribs. On the seventh rib the insertion is on the middle third of the costal cartilage, on the eighth on the external half of the same, on the ninth half on the cartilage half on the bony rib, while on the tenth, eleventh, and twelfth it is on the anterior end of the bone. The fascicle to the twelfth is quite variable in size and may be entirely wanting. These insertions interdigitate with the tendons of origin of the transversalis abdominis. The last three intercostal spaces are spanned by tendinous arches upon which muscular bundles are likewise inserted. Luschka, in view

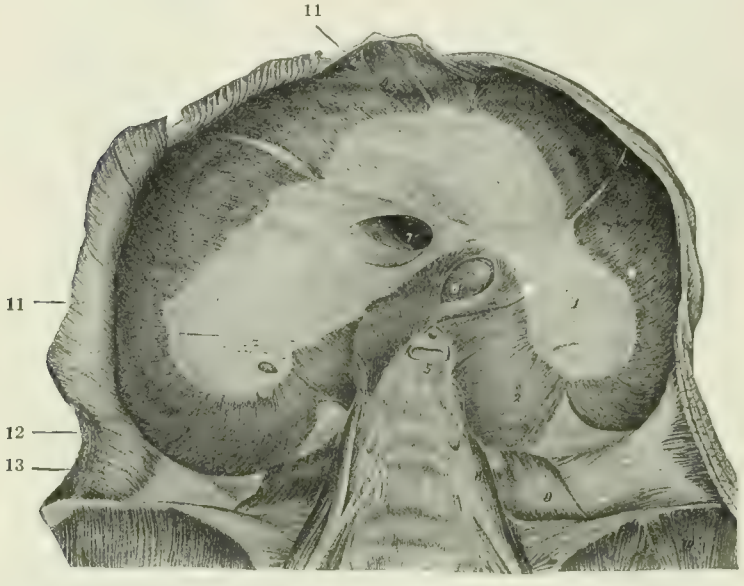


Fig. 1664.—Diaphragm; Under Surface. 1, Central tendon; 2, pars lumbalis; 3, pars costalis; 4, pars sternalis; 5, hiatus aorticus; 6, hiatus œsophageus, with the pericardial sac; 7, foramen venæ cavæ; 8, psoas muscle; 9, quadratus lumborum muscle; 10, iliacus muscle; 11, transversus abdominis muscle; 12 deliquus internus muscle; 13, obliquus externus muscle. (After Eisler.)

of the fact that the lateral lumbocostal arch stretches from the last rib to a costal element of the first lumbar vertebra, groups all these together as the *intercostal* portion of the diaphragm. The costal fibers from the eighth or ninth rib are the longest. They decrease in length slowly to the rear, where they have a steep course, more rapidly toward the front.

The sternal portion (*pars sternalis*, BNA), is much smaller than the others, consisting of a few fibers, usually collected into two bundles that proceed from the central tendon or from the aponeurosis of the transversalis abdominis to the xiphoid process of the sternum. There may be an interval between the two bundles and there is usually a narrow space between the sternal and the costal portions (*trigonum sternocostale*, Rauber-Kopsch). It was here that Larrey proposed to puncture the pericardium, hence the space is sometimes called Larrey's gap.

Orifices.—The diaphragm has a number of orifices through which important structures pass. The aortic opening (*hiatus aorticus*, BNA) has already been mentioned. It is behind the diaphragm rather than through it, and is situated at about the level of the upper half of the body of the first lumbar vertebra, somewhat to the left of the median line. The orifice is slit-shaped, about thirty-five millimeters high by ten to twelve millimeters wide, and transmits the descending aorta and the thoracic duct, surrounded by some loose areolar tissue which may serve as a channel for purulent collections. Muscular fibers arise from the arch that spans this opening, so that during the contraction of the diaphragm it is held open or even somewhat enlarged, and no interference occurs with the passage of fluid through the vessels it encircles.

The esophageal opening (*hiatus œsophageus*, BNA) is, on the contrary, so embraced by muscular fascicles that it forms a sphincter for the lower end of the food-tube, closing it when the diaphragm is in action. It is situated at about the level of the tenth dorsal vertebra, a little farther to the left than the aortic opening. "It is elliptical in shape, being thirty millimeters long by ten to twelve millimeters wide and transmits, besides the esophagus, the vagus nerves, often the phrenico-abdominal branch of the left phrenic nerve, and branches of the esophageal vessels, all closely embraced by the margin of the orifice.

The caval opening (*foramen venæ cavæ*, BNA; *foramen quadratum*) offers still another variety. It is situated in the central tendon near its posterior border at the junction of the right and ventral leaflets, somewhat higher than the others, being about on a level with the ninth thoracic vertebra, fifteen to twenty millimeters to the right of the median line. Elliptical or oval in shape, with a long diameter of thirty to thirty-five millimeters, it may appear quadrilateral owing to the arrangement of the surrounding bundles of connective tissue. It transmits the inferior vena cava which here receives several hepatic veins, one usually emptying above the diaphragm, and usually the phrenico-abdominal branch of the right phrenic nerve. Being completely surrounded by unyielding tendon which is firmly attached to the external coat of the vein it does not vary in caliber during the action of the diaphragm, and the suction of the thorax is thus exercised upon the cava and the hepatic veins, aiding materially in the circulation of the blood.

Besides these principal orifices there are a number of accessory ones somewhat liable to variation. These are as follows:

That between the intermedial and lateral crura through which the great sympathetic nerve has its course, accompanied by the azygos (or hemiazygos) vein. The latter may, however, run between the medial and intermedial crura, or, rarely, seek the aortic orifice.

That between the medial and intermedial crura through which the greater and lesser splanchnic nerves usually pass. The lesser may accompany the aorta or the sympathetic.

That under the lateral lumbocostal arch where pass the iliohypogastric and subcostal nerves. The latter may, however, penetrate the fibers of the diaphragm or pass through the costolumbar hiatus when those fibers are wanting.

That between the sternal and costal portions where pass the internal mammary vessels to anastomose with the superior epigastric; and here too the lymphatics from the liver ascend to join the mediastinal glands and certain branches of the phrenic nerve may pass into the abdomen.

Relations.—As a consequence of its position between the thorax and the abdomen, the diaphragm

is in contact with four serous sacs, the pericardium and the two pleural sacs upon the cranial or convex surface, the peritoneum upon the concave surface. In quadrupeds the pericardium is not adherent, but in man, apparently because of the erect position, it has become so, causing a depression of the vault and occupying a triangular area corresponding mainly to the ventral leaflet of the central tendon, but exceeding that and overlying the muscular fibers on the left by about twenty-five to thirty millimeters. Cardiac impulses are therefore conveyed to the epigastrium, and irritation near the cardiac end of the stomach is popularly thought to have something to do with the heart ("heart burn," etc.).

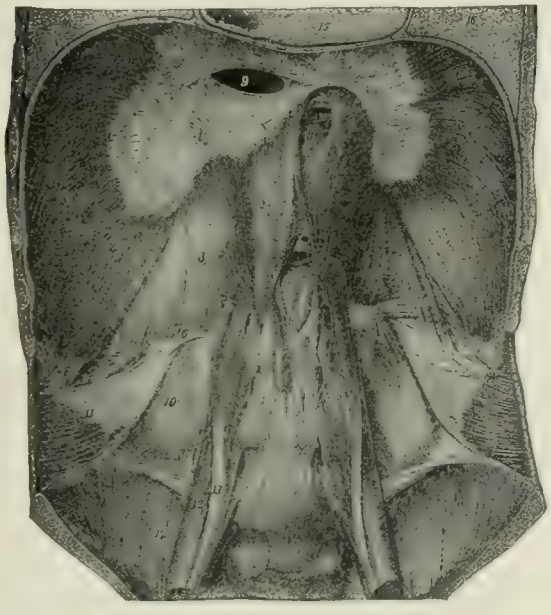

Fig. 1665.—Diaphragm; Ventral Aspect of the Dorsal Portion. 1, Central tendon; 2, crus mediale; 3, crus laterale of the pars lumbalis; 4, pars costalis; 5, arcus lumbocostalis medialis; 6, arcus lumbocostalis lateralis; 7, hiatus aorticus; 8, hiatus œsophageus; 9, foramen venæ cavæ; 10, quadratus lumborum; 11, transversus abdominis; 12, psoas major; 13, psoas minor; 14, iliacus; 15, heart; 16, 16, lungs. (After Eisler.)

On either side of the pericardium the pleural sacs clothe the diaphragm. The lungs do not fill the entire sacs as there is left at the lower part a complementary space (*sinus phrenicocostalis*, BNA) between the diaphragm and the thoracic wall. A penetrating wound here may pass through both the costal and diaphragmatic layers of the pleura, pierce the diaphragm, and reach the cavity of the abdomen without involving the lungs.

This peculiar arrangement of the coverings makes it possible actually to observe the action of the muscle by what is known as the diaphragmatic shadow (Litten's phenomenon). If a moderately lean person is placed on his back with his feet toward the light, no cross-lights interfering, a short, narrow shadow may be seen during inspiration to move down along the axillary line from the seventh to the ninth or tenth rib, as the ribs rise. This is caused by the "peeling off" of the diaphragm from the costal wall. During expiration the shadow rises, but is not so easily seen.

The concave surface of the diaphragm is lined by peritoneum except where the coronary ligament is attached. An extraperitoneal space occurs on the right side between the folds of this ligament where the liver is immediately adherent to the diaphragm. It is a triangular area opposite the transverse processes of the tenth, eleventh, and twelfth thoracic vertebræ and extending from the caval opening along the line of the eleventh rib. A bullet entering the body in this region could traverse the diaphragm and enter the liver without wounding the peritoneum. Through the coronary ligament and the central tendon the weight of the liver (about three and one-half pounds) is conveyed to the pericardiac ligaments and the deep cervical fascia. Double folds of peritoneum pass from the concave surface of the diaphragm to various regions: the falciform ligament of the liver, the phrenicolienal ligament or suspensory ligament of the spleen, and the phrenicocolic ligament to the splenic flexure of the colon.

The depression caused by the heart divides the diaphragm into two vaults or cupolas, the one on the right, much more capacious and higher, being filled by the mass of the liver, that on the left by the fundus of the stomach and the spleen. A slight dyspnea often occurs from pressure of a distended stomach, and in autopsies it is not uncommon to find the diaphragm softened by the action of the gastric juice. The left suprarenal capsule and kidney, the transverse colon and the splenic flexure also touch the concave surface. The crura have special relations of their own, dorsally with the spine, ventrally with the stomach, pancreas, duodenum, pancreatic and renal vessels, the semilunar ganglion of the sympathetic, and, on the right side, the inferior vena cava.

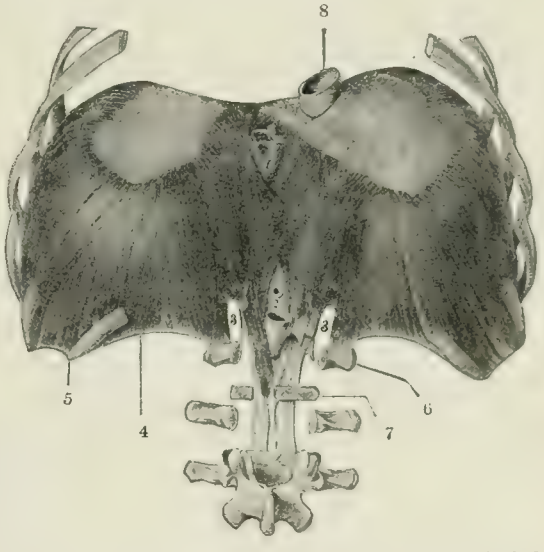

Fig. 1666.—Diaphragm; Dorsal Portion after Removal of the Spinal Column and the Ribs. 1, Hiatus œsophageus; 2, hiatus aorticus; 3, arcus lumbocostalis medialis, above and to the medial side of which is the splanchnic major nerve; 4, arcus lumbocostalis lateralis; 5, 12th rib; 6, transverse process of the second lumbar vertebra; 7, second lumbar intervertebral fibrocartilage; 8, vena cava inferior. (After Eisler.)

Movements.—Supported by the comparative fixity of the central tendon, the diaphragm acts by a shortening and consequent flattening of the curvature of its fibers, which simultaneously pull upon the lower border of the thorax and raise the ribs, causing the cupolas to descend. An enlargement of the thoracic cavity is thus effected, not only from side to side, but from above downward. In this the diaphragm acts like the valve of a great pump, drawing, by suction, air through the trachea and blood and lymph through the cava and the thoracic duct. When the muscle relaxes the abdominal viscera push it back to place. De la Camp and Oestreich, who observed it by Roent-

gen rays, found the excursion of the right cupola to be from 2 to 4 centimeters in males, and 1.75 to 2 centimeters in females.

As the larger mass of the liver lies under the right side, that cupola is the highest. The height varies in different individuals and under different conditions. In young persons, especially females, it may rise to the level of the sternal end of the third rib, in old age not be higher than the fifth intercostal space. An average of a considerable number of observations shows that in ordinary respiration it rises to about the

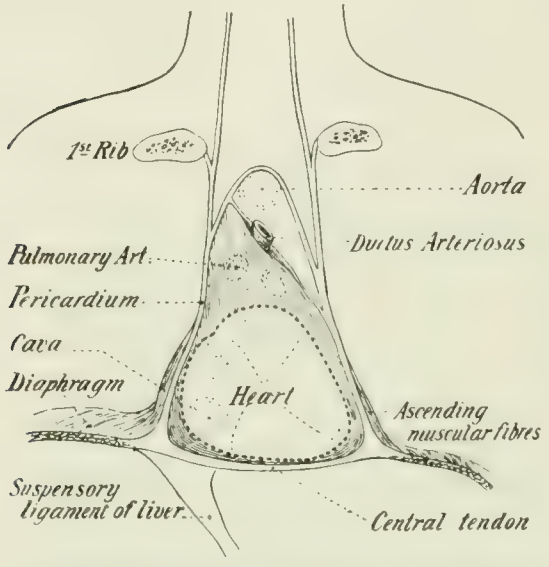


Fig. 1667.—Diagram of the Heart and Pericardium showing their Position with Reference to the Diaphragm. The fibrous portion of the diaphragm is shown as continuous with the deep cervical fascia above. From it pass processes, some of which ensheath the great vessels and others extend to the first rib. Muscular fibers are shown passing from the diaphragm to the pericardium, and it is by their means that the ductus arteriosus is occluded. (Modified from Forbes.)

level of the fifth rib or the fourth intercostal space at the parasternal line in males, and a little higher in females. On the left side it is about one rib lower. It may be affected by pathological conditions, being higher when an enlarged liver, ascites, or abdominal tumors push it up, lower when emphysema, pleuritic or pericarditic effusion, or an hypertrophy of the heart pushes it down. In cases of ovarian tumor and ascites it has been found in the cadaver as high as the second rib, and in cases of pleural effusion as low as the false ribs.

During forced expiration the diaphragm may on the right side ascend almost to the level of the nipple in front, to the angle of the scapula behind. The left side is from half an inch to an inch lower. The central tendon remains comparatively stationary at the xiphisternal junction in front and on a level with the disc between the ninth and tenth vertebræ behind. During forced inspiration it descends on the right side to about the level of the seventh costal arch in front, on the left side to the eighth arch. The supine position is not favorable to the action of the diaphragm, as it throws the weight of the abdominal viscera against its concave surface. Patients suffering from dyspnea are more comfortable when sitting up.

In the cadaver during rigor mortis the diaphragm is in a position between expiration and inspiration, afterward in that of forced expiration, pressed upward by the weight and distention of the abdominal viscera. Some displacement of the vault is likely to occur from the prone position and the transport of the body.

A secondary action of the diaphragm is that of assisting to compress the abdominal viscera and in thus aiding in the evacuation of their contents, as in parturition, defecation, and urination. The muscle is also used in lifting, pulling, etc. This appears to be what may be termed a reversed action, the application of the force being opposite to that of its normal method. In this the movable sheet is kept fixed by filling the lungs and closing the glottis, and the lumbar portion of the muscle is then used to straighten the spine.

Innervation.—Corresponding to the cervical origin of this muscle, its principal nerve, the phrenic, is also cervical, being derived from the fourth cervical nerve with supplementary branches from the third and fifth. It is a mixed nerve, but the motor fibers are far greater in number than the sensory. The former have their deep origin from what Sir Charles Bell called the "respiratory area" of the spinal cord, from the third to the sixth cervical segment. The upper nuclei appear to control the anterior portion of the diaphragm, the lower ones to influence the crura. Lesions of the spinal cord above the level of the sixth nerve are, therefore, rapidly fatal from failure of respiration. The nerve begins as a separate strand at the level of the upper border of the thyroid cartilage, about one inch above the carotid tubercle (transverse process of the sixth cervical vertebra), and proceeds downward and slightly toward the median line across the scalenus anterior muscle. At the level of the cricoid cartilage it is behind the sternomastoid, about midway between the medial and lateral borders of that muscle, overlapped by the lateral margin of the internal jugular vein and crossed by the omohyoid near its intermediate tendon. Near the sternal end of the clavicle, beneath the interval that separates

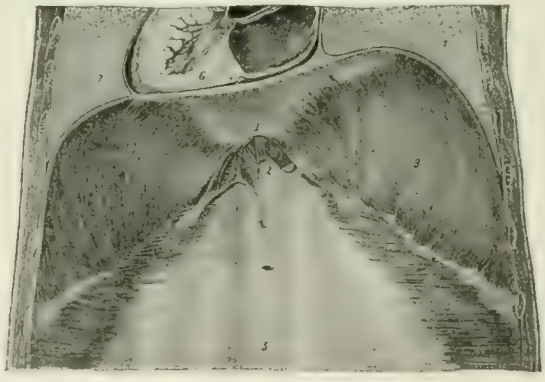

Fig. 1668.—Dorsal Aspect of the Ventral Portion. 1, Central tendon; 2, pars sternalis; 3, pars costalis; 4, transversus abdominis muscle; 5, linea alba; 6, heart; 7, lungs. (After Eisler.)

the two heads of origin of the sternomastoid, it passes between the subclavian artery and vein over the origin of the internal mammary artery and enters the thorax. It then proceeds almost vertically downward, along the summit and edge of the lung, in front of the root of that organ, between the pleura and pericardium to the convex surface of the diaphragm. The left nerve is about one seventh longer than the right because of the lower position of the diaphragm on that side and the fact that it has to bend around the apex of the heart.

In this course it is liable to injury from various

causes. A deep cut or stab on the side of the neck may sever it, pressure upon it from a tumor, an abscess, or an aneurysm of the arch of the aorta may produce that clonic spasm of the diaphragm known as hiccough and finally paralysis. Hiccough may also be caused by pressure upon the nerve from pleuritic or pericarditic effusion or from pressure upon the terminal filaments by a distended stomach. Neuralgia of the nerve is usually accompanied by pain at the region where it enters the thorax. Unilateral division of the nerve, which is sometimes necessary during surgical operations, is not always attended with fatal results, as it paralyzes only one-half of the diaphragm and the other muscles of inspiration supply its place. When both nerves are paralyzed, the abdomen sinks instead of protruding during inspiration, as the diaphragm is unable to push down the abdominal viscera.

The nerves usually divide before entering the muscle. The right nerve sends a large branch to supply the thoracic surface and the sternal and costal portions, and from this a twig may pass through the sternocostal trigone to the abdominal surface. This is mainly supplied, however, by the phrenico-abdominal branch that passes through the foramen for the vena cava or near it, supplies the right crus, and anastomoses with twigs from the sympathetic forming the so-called phrenic plexus, which contains a small ganglion, the phrenic ganglion.

The left nerve breaks up into small filaments having a similar distribution. One group of these, which may be called the left phrenico-abdominal nerve, passes sometimes through the esophageal opening, but more frequently through a series of special orifices in the central tendon just behind the apex of the heart.

The sensory filaments of the phrenic are apparently distributed to the serous membranes lining the upper and lower surfaces of the diaphragm. The pain sometimes felt at the tip of the right shoulder in some disorders of the liver is thought to be a reflex caused by the stimulation of these phrenic filaments. The suprascapular nerve that supplies this region is derived from the same segment as the phrenic. We may also explain in a similar manner the diaphragmatic spasm that often occurs in gallstone colic, and the occasional disturbance of respiration that sometimes complicates operations in this region.

The last five or six intercostal nerves send branches to the periphery of the diaphragm that anastomose with the phrenic, but are now thought to be entirely sensory.

Sympathetic branches from the celiac plexus are also abundant, and form the phrenic plexus, which with its ganglion is thought to contribute to the independence of the muscle. It is because of this independence that a great variety of emotional acts are exhibited by the muscle, such as sighing, sobbing, groaning, laughing, yawning, sneezing, and, with the assistance of the stomach, vomiting.

Vascular Supply.—While no large artery is distributed to the diaphragm, there are a considerable number of small ones from various sources. The internal mammary artery sends a small, slender twig (*arteria pericardiaco-phrenica*, BNA; *comes nervi phrenici* of the old nomenclature) along the course of the phrenic nerve to the convex surface; the musculophrenic and superior epigastric, terminal branches of the internal mammary, each supply the periphery; a branch (superior phrenic) from the thoracic aorta supplies the convex surface; and two branches (inferior phrenic) from the abdominal aorta ramify upon the concave surface.

The veins follow a similar course, emptying into the inferior cava and the renal veins.

Both the convex and concave surfaces are richly supplied with lymphatics which discharge into the mediastinal glands.

Variations.—Congenital defects may occur, indeed the entire muscle has been seen to be absent in very abnormal fetuses. Absence of the entire left half has been reported, and defects are more apt to occur on that side. Want of union of the separate portions of the muscle is not infrequent. Of these the trigonum costosternale and the trigonum lumbocostale are examples. Similar interspaces may occur between the digitations attached to the ribs. Where such deficiencies exist the serous membranes of the thoracic cavity are in contact with the peritoneum and hernias may occur. In these cases it is always the abdominal viscera that protrude.

Supplementary insertions may occur upon the neighboring muscles, as the psoas, quadratus, and transversus abdominis. Bundles passing to other organs have received special names, as the phrenico-esophageal, phrenicogastric, and phrenicohepatic muscles. The muscle of Treitz (*musculus suspensorius duodeni*, BNA,) passing from the left crus of the diaphragm to the duodenojejunal flexure, is thought by many to be an instance of this kind, and to merit the name *phrenicoperitonealis*.

The crura may be more or less blended together. In very powerful individuals the medial crus has been known to extend to the fifth lumbar vertebra.

The lateral lumbocostal arch is subject to some variation in its insertion, extending sometimes to the transverse process of the second, and even to the third lumbar vertebra.

Scattered bundles of the central tendon frequently become muscular, especially upon the right side, and usually on the abdominal surface. Frank Baker.

**Diaphragm, Diseases and Injuries of the.**—Since the diaphragm is composed of tendons and muscles and innervated by a nervous apparatus, not materially differing from similar tissues found in other parts of the body, it is subject to the diseases common to such tissues in all parts of the organism. Few of its affections are limited to its own tissues, and frequently its symptoms are merely a part of a general symptom complex which has its origin in a diseased organ more or less remote from the diaphragm.

Displacements and impairment of the movements of the diaphragm may be due to loss of tone and elasticity of the musculo-tendinous structure, but by far the most frequent agent in producing such conditions is a change in the balance of the intrathoracic and intra abdominal pressures. Increased intra thoracic pressure frequently depresses the diaphragm; this may be unilateral or bilateral. It is produced by tumors of the lung, pleura, or mediastinum, by collections of fluid or gas in the pleura, and by loss of lung elasticity as in pneumonia, emphysema, etc. Increased intra abdominal pressure often raises the elevation of the diaphragm; this is usually bilateral, rarely unilateral. This may arise from pregnancy, cysts, and tumors of the abdominal viscera, from ascites and inflammatory exudates as in peritonitis, subphrenic abscess, etc., and from accumulations of gas, intra peritoneal or intra intestinal. Displacement may be produced by pleuritic, peritoneal, or pericardial adhesions, by a kyphosis of the spine, or by the pull of an enlarged liver. With the change in position there is usually associated a diminution in motion which may be so great as to be entirely lost. In upward displacements there are frequently signs of compression of the lungs at the base; breathing is embarrassed and tends to become costal. Downward displacement is evidenced by a protrusion of the abdominal wall and by the low position of the spleen and liver. Litten's "diaphragm phenomenon"

is most useful in determining changes in position and movements of the diaphragm. It is thus described: When "the patient is made to lie on his back, his head but slightly supported, opposite the window to which his head is turned, while at a distance of three or four feet the observer, with his back toward the window, scans his chest at an angle of 45°," the height and movements of the diaphragm are marked on the thoracic wall by a shadowy line, lying at an acute angle to the ribs, denoting its momentary position. The excursion of the shadow under normal conditions should average two and one-half inches in forced respiration; less than this shows an abnormally impeded movement. In unilateral changes the contrast of the shadows of the two sides is very evident. The skiagraphic study of the diaphragmatic movements is very helpful in the recognition of these conditions. The prognosis and treatment depend upon the cause and its removal.

*Eventration* of the diaphragm, a rare congenital defect, characterized by an abnormally high position of the diaphragm in the trunk cavity, is the result of relaxation due to a congenital deficiency of muscle fibers. The symptoms of this condition are slight or altogether absent. The defect is unilateral and has been described only on the left side where the diaphragm has been found as high as the third rib. It does not interfere with the duration of life. The diagnosis has been rarely made during life, it must be differentiated from hernia, primary defects of the diaphragm, phrenic paralysis and dextrocardia. It is important only since it must be considered in the diagnosis of the above conditions. The signs of this condition are those of unilateral displacement as outlined above. A similar acquired condition has been described by Lahn.

*Phrenoptosis*, the antithesis of eventration, that is a downward displacement of the diaphragm, may be merely the accompaniment of a general enteroptosis.

Traumatisms to the diaphragm rarely occur without concurrent injuries to adjacent organs, and the symptom complex afforded by the latter often masks those of the former. Blows and falls causing rupture or strain of the musculo-tendinous tissue may occur without evidence of injury to the external parts. Rupture is frequently the result of blows and wounds to the lower chest, stab wounds intended for the heart and fractured ribs being especially in evidence. Men, as they are especially exposed to trauma, are more commonly the subjects of this lesion. On account of loss of elasticity of muscle the aged are more liable to rupture. The left is the side most frequently affected, probably because wounds are more frequently directed toward this side, and the liver, on the right side, prevents the development of complications calling attention to the injury to the diaphragm. The symptoms of diaphragmatic injury are usually secondary in importance to those of other organs coincidently injured. There is considerable shock, at times passing into collapse. The face is drawn (risus sardonicus), nose pinched. The respiration is embarrassed and there is pain at the site of diaphragmatic attachment. Not infrequently there is a resulting hernia. The diagnosis is often overlooked in considering the trauma to other organs. The prognosis is usually grave.

Treatment is as a rule necessarily first directed to the coincident injuries to adjacent organs and to meeting shock by the usual methods. The edges of the wound may be closed either by suture to each other or, as in a case reported by Frey, by suturing one edge also to the chest wall. It should be borne in mind that hemorrhage from a wound of the chest may be from the diaphragm as well as from the lung and the thoracic wall.

Hernia.—Herniæ of the diaphragm are not very rare. Leichtenstein has collected 252 cases and Lacher 276 cases. By hernia is understood any escape of the organs, normally lying below the diaphragm, through the diaphragm into the chest cavity, whether the escaped organs are enclosed in a true hernial sac or not. Eppinger has collected 655 cases, of these 304 were congenital and 351 acquired; only seventy-four were provided with a sac and may therefore be classified as *true herniæ*.

*Congenital herniæ* are due to an arrest of fetal development and occur usually on the left side, since congenital defects of the diaphragm are more frequent on the left side, and the muscle congenitally deficient is protected on the right side by the liver. In 274 congenital cases Eppinger found 248 of the left side, against thirty-six of the right side; a sac was present in thirty of those occurring on the left side and in six of the right side. The opening is more frequently in the muscular than in the tendinous structure, and more often in its posterior portion. The size of the aperture varies from a small hole to one involving one-half of the diaphragm. Often these defects of the diaphragm are associated with other congenital defects (hemicrania, anencephalia, defective fingers, toes, etc.). These infants are at times still-born or at best they live a few hours, although there are rare cases on record of the patients reaching maturity and even old age. Living babies suffering from this condition are very cyanotic, and after a longer or shorter period of labored breathing reach the fatal termination. If the diagnosis is made the little patient may be held erect in the hope that gravity may assist in bringing about a reduction of the hernia; water pressure by rectal injection has been advocated. No case of operative interference is on record.

*Acquired Herniæ* are usually the result of a traumatic rupture of the diaphragm, but there are also records of rare cases of hernia through a weak point in the diaphragm (sometimes coincident with one of the natural openings, *e.g.* the aperture for the esophagus), following the excessive intra abdominal pressure of labor, vomiting, and the like. They are mostly found in men, who are more liable to injury than women. In looking over the literature I have found only one case following pathological perforation. Lacher reports 150 cases following traumatism; the hernia occurred on the left side in 127 cases, only three cases being provided with a sac. Of the 351 cases collected by Eppinger, 332 were of the left side and nineteen of the right side; a sac was present in twenty-three of those situated on the left side and in fifteen of the right side. The greater frequency of left-sided hernia is explained by the greater number of injuries to the left side of the chest and the absence of protection by the liver. Through the ruptured or defective diaphragm any of the abdominal organs may find their way into the chest cavity. The following is a list of the organs (in order of frequency) thus found displaced: stomach, omentum, colon, small intestine, liver, duodenum, pancreas, cecum, and kidney. If the opening in the diaphragm has existed for any considerable period the edge is found smooth, thickened, and rounded. Adhesions between the displaced organs and between these and the diaphragm are of exceedingly rare occurrence. An organ at one time a part of the hernial protrusion may find its way back to its normal abdominal position, thus materially affecting the clinical picture.

In traumatic hernia, injuries to other organs may completely mask the symptoms of the hernia proper, but as the early symptoms pass away the evidences of the hernia usually make themselves apparent. The physical signs vary considerably according to the viscus which is displaced, its volume, and its position. The lower chest appears full, the abdomen hollow; respiration is costal, the respiratory movements of the abdominal wall being absent or greatly reduced. Litten's "diaphragm phenomenon" indicates movements diminished, absent, or unequal on

the two sides. Dyspnea is usually an early and prominent symptom. Palpation shows diminished movements of the liver, spleen, and stomach in inspiration, or a displacement of these organs from their normal position. The heart is frequently displaced, usually backward and to the right. The hand placed on the chest may often detect the movements of the displaced intestine. Percussion shows a compressed or collapsed lung replaced by signs of a viscus solid or containing fluid or gas. By auscultation, in addition to the change in the lung and the embarrassed condition of the heart, one may hear the movements of the stomach and intestines and the splashing of their contents within the chest, often with succussion and metallic tinkle, while the deglutition sounds may show a wide variation from the normal. Abnormal friction sounds may be present. Subjective symptoms are liable to extreme variations with the change in the volume and the position of the hernia. The dyspnea may be continuous or paroxysmal and attended by extreme cyanosis. The pain may be considerable and is increased by movement; it is usually referred to the site of the attachment of the diaphragm to the body wall. Cough, hiccough, and vague gastric disturbances may exist. If strangulation of the bowel supervenes, the symptoms of acute intestinal obstruction may be added to the picture.

A number of cases are on record in which the hernia existed for years, some with very mild and others with severe symptoms, only to be revealed on autopsy. One patient lived fifty-two years after the occurrence of the hernia. Doubtless many patients recover without a discovery of the lesion. In general, however, the prognosis is bad. In thirty-three cases following stab wounds there was a mortality of eighty-eight per cent. It should be borne in mind that the gravity is greatly augmented by trauma to some of the organs involved and the resulting complications, prominent among which are perforation of the stomach and empyema. Strangulation is always to be dreaded, and may occur years after the original injury, being induced by some unusual effort, as an attack of vomiting, coughing, straining, etc. Death from strangulation of the stomach or intestines occurs, according to Leichtenstein, in fifteen per cent. of the cases. Another frequent cause of death is the compression of the lungs and heart by the distention of the displaced viscera by gas or the sudden passage of additional organs through the hernial opening.

*Diagnosis.*—Among the more important diagnostic points may be mentioned: fulness in the chest associated with a hollowed abdomen, evidence of movements of the intestine and its contents in the chest, and the displacement of the heart. Hernia is most often mistaken for pneumothorax. The latter usually occupies the entire half of the thorax, is about equally frequent on both sides of the chest, is absorbed gradually; the physical signs are fairly constant, and there is frequently an antecedent history of disease of the lung or pleura. Hernia usually occurs on the left side, occupies an irregular portion of the thorax; its volume and position change from day to day, affording great variation in physical signs, and the subjective symptoms are subject to greater variation. Fluoroscopic observation is a valuable aid in the study of these cases. Rœntgen ray photographs taken after the ingestion of bismuth may show the stomach or a large coil of intestine occupying a considerable portion of the thoracic cavity.

On account of the frequency with which hernia results from stab wounds of the lower chest, Paget recommends that every such wound should be thoroughly explored as soon as it comes under observation so as to exclude positively every case of hernia.

*Treatment.*—All adjacent organs should be carefully examined and their injuries cared for. The reduction of the hernia can be accomplished much more easily from the chest cavity than from the abdomen, and since the diaphragm is also far more accessible from above, the avenue of approach should be through the chest wall. Access should be obtained by resecting several ribs, thus allowing a large flap of chest wall to be raised. The prolapsed organs, after being cared for, are reduced and the diaphragm closed by strong sutures; the reduction may necessitate an increase in the size of the diaphragmatic opening. Through such an opening it has been possible to close a perforation of the stomach and cleanse a large portion of the viscera, the case resulting in recovery. The chest wall is replaced, a sufficient opening being left to permit of a small drain reaching to the site of injury. Over 300 cases are reported in the literature which have been successfully operated upon.

Diaphragmitis.—Primary inflammation of the diaphragm is an extremely rare condition and its existence is denied by several writers. Primary localized inflammation of its serous coverings is not uncommon. Waldeyer has reported a case of diaphragmitis following puerperal sepsis in which the lymphatics of the diaphragm were swarming with microorganisms. The lymphatic and other paths by which infection travels through the diaphragm have been carefully studied by McCallum (Johns Hopkins Hospital Bulletin, 1903, xiv., p. 146). The process may result in a fatty degeneration of the muscle fibers. There are usually a sense of constriction in the epigastrium; pain at the line of insertion of the muscle, increased by pressure on the epigastrium and by the movements of respiration; embarrassed breathing, cough, singultus, and fever. A differentiation between this and localized pleurisy or peritonitis is difficult and is rarely made during life. Treatment consists of rest and the administration of morphine for the pain.

Perforation.—Perforation is produced by a localized suppurative process, usually by the burrowing of pus upward or downward, and by the extension of neoplasms. The common etiological factors are empyema, purulent pericarditis, suppurative hepatitis, subphrenic abscess, and perforating ulcer of the stomach. In 28 cases of ulcer of the stomach causing perforation of the diaphragm, 20 were found to have produced this directly, and in only 8 was a subphrenic abscess formed before the perforation. Treatment should be directed to the underlying cause.

Adhesions.—Adhesions between the diaphragm and neighboring organs (either thoracic or abdominal) are of common occurrence. They are usually the result of the inflammation of the pleura or peritoneum of this region, and are commonly elastic bands which are occasionally infiltrated with calcareous material and do not hold the adjacent organs very closely or firmly together. When adhesions exist between the diaphragm and the pericardium, there is pulsation visible in the epigastrium. Other adhesions may cause displacement or impede the movements of the diaphragm.

Rheumatism.—Rheumatism may attack both the muscular and the aponeurotic structures of the diaphragm. It may be acute or chronic; the acute form may be idiopathic or may be associated with rheumatism in other parts of the body. The attack comes on suddenly, usually after exposure to damp and cold with chilling of the body surface. There are systemic symptoms only when this is a part of a general rheumatic affection. Pain at the line of attachment of the muscle to the body wall is severe and is increased by movements and pressure; it may often be marked out by palpation; only rarely is it unilateral. Food passing the esophageal opening may cause distress. Pain embarrasses the movements of the diaphragm and respiration becomes costal.

There may be tonic or clonic spasm of the diaphragm with hiccough, also spasms of the esophagus and larynx. The diagnosis is sometimes difficult. The conditions most frequently confounded with it are pleurisy, intercostal neuralgia, asthma, and angina pectoris. Rheumatism in other parts of the body, the absence of pleuritic râles, and the location of the pain will aid in establishing a diagnosis. The prognosis is nearly always good. Anti-rheumatic treatment affords the most satisfactory results, notably the administration of the salicylates with alkalies. Physiological rest is important and may be assisted by strapping the lower chest with broad strips of adhesive plaster. Locally cupping and painting with tincture of iodine are of service. Morphine may be necessary to relieve the pain.

Neoplasms.—Neoplasms of the diaphragm are secondary to growths in adjacent parts. The diagnosis is made during life only in extremely rare cases; they are in the main postmortem curiosities. Grancher has reported one case of primary new growth. The forms met include cancer, tuberculosis, hydatid cysts, and calcareous deposits associated with muscle degeneration (Otto); the latter seems to be frequently produced by a long-existing pleurisy. Cysts and lipomata have been described. Perforation of the diaphragm has occasionally been produced by neoplasms.

Nervous Affections.—The affections of the diaphragm due to a traumatic or diseased condition of its nerve supply may be considered under the headings of neuralgias, spasms, paralyses, and atrophies. As the phrenic nerve conveys by far the most important nerve impulses to and from this organ, the changes in this nerve and in its centers in the spinal cord include the major portion of such affections, while changes in the intercostal nerves may be practically disregarded in this connection.

*Neuralgias* are not uncommon affections, their etiology being much the same as that of neuralgias of other nerve areas; a sudden chilling of the body, nutritional disturbances as in anemia and rheumatic affections, and inflammatory processes in adjacent organs, such as pleurisy and pericarditis, may be mentioned as especially prominent. Pressure on the phrenic nerve in the neck by a tumor or an enlarged thyroid gland may cause a persistent neuralgia in the phrenic distribution. Pain, usually severe, at the line of attachment of the diaphragm to the chest wall, sometimes radiating to the shoulder, is always present. The pain may follow the course of the phrenic nerve in the neck. The pain often interferes with respiration. There may be dysphagia. Diaphragmatic neuralgia is often confounded with angina pectoris, pericarditis, and pleurisy. The treatment consists in removing the general causal condition, in the local application of revulsives, and in the hypodermatic use of morphine, antipyrin, etc.

*Spasm* of the diaphragm is rare, excepting when it is secondary to some general disease, which is usually a neurosis. Spasms may be tonic or clonic, the latter being far more common and less serious than the former. While rare cases of idiopathic *tonic spasms* have been described by Duchenne and others, by far the greater number are symptomatic and are merely developed in the course of some general disease. Of these may be mentioned epilepsy, asthma, eclampsia, rabies, tetanus, and strychnine poisoning. The spasms may be short or may continue for a considerable period, the respiration is altered to the costal type, the thorax is enlarged at the base and the liver is pushed down. There are attacks of dyspnea and a feeling of suffocation with pain encircling the body like a girdle. As the suffocation verges on asphyxia all the accessory muscles of respiration are brought into play. There is a diminished vesicular murmur over the lower part of the lungs. If the spasm is short, the patient soon resumes normal breathing; if long, he dies with the agonies of asphyxia. To relieve the condition, energetic counterirritation should be applied to the thoracic walls, epigastrium, and lumbar regions, the actual cautery, hot compresses, and wet or dry cups being especially serviceable. The faradic brush, applied along the line of attachment of the diaphragm, has also accomplished good results. As antispasmodics one may employ chloroform, ether, valerian, the bromides, and the nitrites.

*Clonic spasm* of the diaphragm occurs far more frequently than the tonic; there is no idiopathic type, and it occurs only as a symptom of some causal disease. The subjects of such a spasm are usually of a neurotic temperament. The main etiological condition is an irritation of the respiratory centers. This may be functional, as in hysteria and epilepsy; it may follow a central or spinal lesion or poisoning, as in typhoid, septicemia, uremia, etc.; or it may be the result of reflex irritation from a peripheral source, *e.g.* stricture of the esophagus, intestinal and gastric affections, overloading of the stomach, peritonitis, disorders of the pleura, pericardium, liver, bladder, uterus, etc. The contractions of the muscular apparatus vary extremely in force and frequency. From one a minute they may, as in some observed cases, increase to one hundred a minute when the successive movements form a continuous tremor. The diaphragm strikes violently against adjacent viscera and pushes them about. With each inspiration the whole abdomen is raised and there is often a peculiar succussion sound. In the common form the ordinary hiccough is the most evident manifestation; so common is it that many writers consider it synonymous with clonic spasm of the diaphragm. Speech is interrupted and inarticulate noises accompany each spasmodic movement. A small group of these cases occurring in patients of a neurotic disposition may be considered true spasmodic tics. There is the quick, convulsive movement of the diaphragm followed by an explosive expulsion of the breath, with a harsh rasping noise. When the patient is noticed or becomes excited the spasms increase in frequency. If these spasms pass away quickly the patient soon regains his normal status; but if they are long-continued (cases lasting several weeks are on record), the patient becomes exhausted with the movements and consequent loss of sleep.

The prognosis depends on the cause and the duration of the attack. It is not as dangerous as the tonic spasm, but may seriously interfere with the ingestion and assimilation of food. Of the tics it is said they "rarely shorten life." The prognosis is bad in adults, but good in children if the affection is taken in hand early. Treatment should be directed to the cause, which should be removed, if possible; general tonics, moral control, with rest and massage, have their place. As symptomatic treatment innumerable methods have many zealous advocates. Among these are: holding the breath for long periods, pressure over the phrenics in the neck, pressure or ethyl chloride spray on the epigastrium, galvanism and faradism (one pole over each phrenic, or one over the phrenic and one at the diaphragm), and the administration of atropine, hyoscine, anesthetics, nitrites, and morphine.

*Paralysis* of the diaphragm may follow injuries, inflammations, or pressure on the phrenic nerve in its peripheral course, or at its origin in the second, third, and fourth segments of the cervical cord. The common site of injury to the phrenic nerve is in the neck, where its protection is less than in other parts of its course. A neuritis involving the phrenic may follow diphtheria, beriberi, influenza, rheumatism, and poisoning by lead, alcohol, coal-tar products, etc.; or it may be a direct extension from neighboring inflamed organs as in pleurisy. Pressure may be the

result of tumors of the neck or mediastinum. Paralysis of the diaphragm also occurs with pathological processes of or injuries to the upper cervical segments of the spinal cord. Among the pathological processes may be mentioned fractures of the spine, tumors, hemorrhages, anterior poliomyelitis, tuberculous or other chronic inflammatory affections, as amyotrophic sclerosis, bulbar palsy, ascending myelitis, and progressive muscular atrophy. Paralysis also occurs in hysteria and with inflammations of the lungs and pleura; in the latter the movements of the diaphragm are inhibited by the reflex pain. The loss of diaphragmatic function may be unilateral or bilateral, and again it may be complete or partial. In complete bilateral paralysis the breathing is costal and may be easy while the patient is at rest, but the least exertion induces marked dyspnea; there is a feeble voice, embarrassed by inspiration, or complete aphonia, Palpation fails to reveal descent of the diaphragm, and the abdominal wall sinks in inspiration and bulges in expiration. Litten's sign is absent. There is loss of vesicular murmur over the base of the lungs and the fixing of the diaphragm for coughing, straining at stools, etc., becomes impossible. When the paralysis is unilateral, the loss of function on one side may be so compensated by the mov ments of the other that the paralysis is not evident. If the patient is directed to take deep inspirations, the difference between the two sides will show plainly; furthermore, in this condition the contrast between the two sides, as shown by the Litten's diaphragm shadow, is particularly marked. Following the defective respiration bronchitis often develops in the lower lobes, and the exudate is coughed up with the greatest difficulty. The diagnosis is at times easy, at other times extremely difficult; the changes in the respiratory movements, the loss of Litten's diaphragm phenomenon, the aphonia, and the weakening of the vesicular murmur are important points in differentiating this from other affections. A fluoroscopic examination reveals the partial or complete immobility of the diaphragm. The functional excitability of the phrenic nerve may be studied by electrical stimulation. The prognosis, while favorable in rheumatism and hysteria, is extremely grave when the paralysis arises from other causes. It varies according to the extent of muscle involved. If the paralysis is complete, a fatal asphyxia may come with the slightest exertion; this is the final termination of many diseases instanced above as among the causes of paralysis. Treatment should be directed primarily to the underlying cause. Locally electricity has proved of great value, in some cases faradism and in others galvanism being found most efficacious. One pole should be placed over the phrenic nerve in the neck, the other over the abdomen just below the diaphragm. A current passed transversely through the diaphragm has also been found to work satisfactorily.

*Atrophy* of the muscle of the diaphragm may occur in any of the general diseases which cause muscular atrophy in other parts of the body. It occurs as a result of the destruction of its motor nuclei in the spinal cord (in spinal progressive muscular atrophy), as a result of a peripheral neuritis involving the phrenic nerve, and as a myopathic condition (in pseudohypertrophic muscular paralysis and idiopathic muscular atrophy). The symptoms depend on the weakness following the muscular atrophy, which ultimately results in complete paralysis. It has been discovered postmortem in patients dying of bronchitis, emphysema, interstitial pneumonia, and pericarditis. The dyspnea and asphyxia, of which it is the cause, are frequently the closing features of the diseases above enumerated. The prognosis is bad. Treatment has been of small avail. When the spinal disease is of syphilitic origin, mercury and potassium iodide or the intraspinous administration of salvarsanized blood serum may arrest the disease. For the atrophy of myopathic origin, arsenic, nitrate of strychnine, and galvanism have been recommended.

Subphrenic Abscess.—Subphrenic abscess is not a rare condition, although it is only in comparatively recent years that this name has been applied to localized collections of pus having the under side of the diaphragm as one of its boundaries. The etiology of this lesion comprises two factors: a source of bacterial infection and a localizing agent. It may be a part of a general infection as in pyemia, septicemia, or tuberculosis. Trauma may act as the localizing agent, while infection may travel by metastasis from a distant infected area, by means of the lymphatics so abundant in this region, or by direct invasions from neighboring organs. Prominent among these are ulceration of the stomach, duodenum, and colon, appendicitis, abscess of the liver, suppurating echinococcus cysts, perforation of the gall-bladder and bile ducts, and empyema. In reporting the etiology of 666 cases which he had collected from the literature, Eppinger found the distribution of the sources of infection was as follows: appendix, 190; stomach, 177; liver and bile passages, 60; echinococcus cysts, 37; perinephritis, 27; thoracic, 25; metastatic, 24; traumatic, 19; duodenum, 18; spleen, 13; intestine, 13; costal, 8; female genital organs, 8; unknown, 260.

A classification of subphrenic abscesses naturally arranges them as intra- or extraperitoneal; the latter occur far more frequently on the right side. Since the falciform ligament forms a natural barrier, the abscesses are usually confined to one side. Those of the right side occupy the space between the diaphragm and the liver; those of the left have the diaphragm above and posteriorly, and for their other boundaries some part or all of the following organs, which are commonly matted together by adhesions; stomach, spleen, transverse colon, and the left lobe of the liver. Any one of these may have been the chief causal factor as a starting-point for the infection. The abscess may often be considered as a localized encysted peritonitis; it may vary in size from that of an egg to a cavity holding over two liters. The edges are, as a rule, rough and lined with fibrinous pouches; a few have smooth walls. The contents may be pus alone or pus and gas. The pus may be thick and devoid of odor, or ichorous, mixed with necrotic tissue, putrid and fetid, and colored by the pigments of bile or blood. Gas may come from a primary opening, from an organ containing gas from a secondary opening formed by the abscess breaking into such an organ, or from gas-forming bacteria. Of Maydl's 179 cases 47 contained gas; of these, 20 came from primary perforations from the alimentary tract, 18 from secondary perforations (16 into lung and 2 into alimentary tract), and 9 from gas-forming bacteria, no perforation being present. Among the microorganisms found the *Bacillus tuberculosis*, *Micrococcus tetragenes*, staphylococci, Eberth's bacilli, and the *Bacillus coli communis* have been isolated. Osler considers the finding of *Bacillus coli communis* helpful in proving the alimentary tract as the source of infection. The diaphragm is pushed up and is frequently adherent to the lower ribs. Pleurisy and pericarditis, serous or purulent, may exist as cause or effect. The abscess, if left to itself, most commonly perforates the diaphragm, infecting the pleural cavity and the lung. The destructive process may reach the bronchi, which may afford sufficient drainage for complete evacuation and spontaneous cure. Other paths of exit are through the abdominal wall and into some part of the alimentary canal.

The clinical features of subphrenic abscess are greatly modified by the associated lesions and may accordingly have extreme variations. While at times the respiratory functions are so modified as to make this aspect the most prominent, it is more usual for

the symptom complex to suggest an abdominal lesion. The symptoms may be obscure and develop slowly, or, as in cases due to the perforation of a gastric ulcer, they may be very evident and may accumulate with extreme rapidity. There is usually considerable pain in the hypochondriac or epigastric region, often radiating to the shoulder, with or without tenderness. The pressure on the diaphragm and the pain embarrass respiration, making it short and superficial in character, with more or less dyspnea. The inflammation of the peritoneum is evidenced by meteorism, vomiting, hiccough, and general depression, with rapid, weak pulse. There may be signs of a general pyemic infection, with rigors, fever, and sweating. The abscess may cause a bulging of the upper abdomen or lower part of the chest, with superficial heat and redness associated with nature's attempt to form an exit externally. The region in which these abscesses commonly point is near the ensiform cartilage. The ribs may be displaced, lying more horizontally than normal, and separated by broader intercostal spaces. Palpation may show fluctuation when the collection of pus is superficially placed, friction from the surrounding peritonitic exudate, a liver or spleen displaced downward, and, when the abscess cavity is partially filled with gas, succussion. Percussion elicits dulness over the lower part of the chest and upper abdomen continuous with that of the liver or spleen, or, if gas is present, amphoric and metallic resonance and obliteration of normal hepatic or splenic dulness. Amphoric breathing, splashing, and metallic tinkling may frequently be heard, closely simulating the signs of a pyopneumothorax. The clinical picture may vary from day to day as in cases in which the abscess cavity, originally filled with pus, is additionally distended with gas. Perforation of the diaphragm, with its resulting empyema, rupture into the lung, and evacuation of the cavity through a bronchus, are features not infrequently added. If the abdominal adhesions are broken down a fatal peritonitis rapidly follows. The condition lasts for from fifteen days to several months, and is usually fatal unless relieved by operative interference. In a number of cases evacuation may take place through a rupture into a bronchus, into some portion of the alimentary tract, or externally, the latter being an extremely rare occurrence. Death results from general sepsis, empyema, rupture of the pericardium, or abscess of the lung, or from peritonitis. This condition is frequently difficult to diagnosticate from empyema and pyopneumothorax. The exploratory needle may assist in locating the cavity, but it should only be used when means are at hand to operate for the relief of the condition, on account of the danger of serious extension of the infection along the path of the needle. If a cannula be thrust into the abscess, its contents are expelled in inspiration more forcibly than in expiration—contrary to that which occurs when the pus is above the diaphragm (Pfuhl). This sign may be absent when the diaphragm is paralyzed as a result of long-existing inflammation, or if the diaphragm and lung are perforated. In subphrenic abscess the upper line of dulness usually follows the convex curve of the diaphragm, and the lateral line of dulness runs from before backward and from above downward, quite contrary to the usual outlines of an empyema. In pyopneumothorax there is usually an antecedent history of disease of the lung, the whole chest is enlarged, vesicular murmur is entirely lost, and the heart is displaced laterally, while in subphrenic abscess with gas, the chest is enlarged only in its lower portion, vesicular murmur continues over the upper portion of the chest, and the displacement of the heart is upward. Examination with the fluoroscope may permit of a differentiation of the shadows of pus and gas in the abscess cavity and make evident the impeded movements of the diaphragm. A radiograph after a bismuth meal may show a stomach or colon indented or drawn out of place by the abscess or its attendant adhesions.

Surgical interference is the only treatment which promises a successful outcome. Opening and drainage are indicated as soon as the diagnosis is made, being contraindicated only when a natural opening with efficient drainage has been established. An early operation often prevents that serious complication, perforation of the diaphragm, with its attendant dangers. The site for the incision is chosen by the physical signs and the exploratory puncture; the abdominal route and entrance by means of a resected rib have been about equally employed. If the abscess is situated high up, one or more ribs should be resected, the pleura raised and closed off by a line of sutures, and then the abscess should be opened by an incision through the diaphragm. The abdominal route avoids injury to the diaphragm. The general peritoneal cavity is usually well walled off by adhesions. The subsequent treatment consists of irrigation or dry dressings, according to the demands of the individual case. Uncomplicated subphrenic abscesses heal in from sixteen to twenty-four days after their evacuation by incision (Maydl). Of seventy-six cases operated upon, thirty-nine recovered. Failure after operation is usually due to pre-existing complications. T. Stuart Hart.

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**Diarrhea.**—Diarrhea (from *διάρροια*, a flowing through and especially in the modern sense) is usually defined as an excessively frequent and more or less liquid fecal discharge. René Gaultier contends that the term should be restricted to cases in which there is both an excessive rapidity of alimentary transit and an excess of water in the stools, as determined by exact tests. He administers a test breakfast of white bread 100 grams, beef or mutton sixty grams, butter ten to thirty grams, milk 300 to 500 c.c., potatoes 100 grams, with carmine to color the stools. This is separated from the previous meal by the entire night and no other food is given till the next evening. The colored stool should be passed within twenty-six to forty hours, not necessarily at one time, and the water, removed by evaporation on the water or sand bath, should amount to thirty-two per cent. by weight. He holds that even liquid passages due to the irritation of scybala, long retained, constitute a phase of constipation. Clinically, however, the term diarrhea cannot be reduced to a strict definition. A diet consisting wholly or mainly of coarse indigestible vegetables containing little available nutriment inevitably produces frequent liquid stools, if anything approaching the quantity (ten to thirty pounds a day, according to the analysis of any particular vegetable of this class) yielding the standard of 2,000 to 2,500 calories is taken. But, in spite of the fact that such stools are inevitable, the term diarrhea is applicable, just as the result of a concentrated diet is called constipation.

Neither is it possible to assign an arbitrary limit of

frequency or liquidity of stools in defining diarrhea. A trifling irregularity of peristalsis, even of the final extrusive function, may multiply the number of passages without an alteration of consistence warranting the term diarrhea while, conversely, inhibition of the extrusive function, voluntary or otherwise, may reduce the number of passages of fecal matter of a truly diarrheic consistence. Likewise, a single irritating portion of ingesta may produce a liquid passage without further disturbance. Probably most clinicians would agree that the term diarrhea is warrantable when the passages exceed two a day for any considerable period, or when there are three or four fairly loose passages in any single day, or when the volume of fecal matter—not counting evacuation of retained feces at one time—exceeds a pint a day. The frequent, small discharges, consisting mainly of mucopus with blood, characteristic of dysentery, intussusception, etc., are also commonly included under the term diarrhea, although they may contain scarcely any fecal matter.

Physiologic Considerations.—While both propulsive intestinal peristalsis and segmentation contractions seem by some experiments to proceed without nervous control, at least when the bowel is freed from connection with either primary or ganglionic centers, all movements of the intestine are normally controlled to a large degree by both motor and inhibitor fibers. We may, therefore, consider the direct causes of diarrhea to be inherent excess of muscular contraction, stimulation of motor nerves, ganglia, or centers, and depression of inhibitor nerves, ganglia, and centers. Carrying the explanation one step further back, we may postulate a local lesion or disturbance, either isolated or part of a more general process, a reflex stimulus or a purely chemical action through hormones. It is questionable whether a true diarrhea ever occurs without the active participation of the intestinal muscles, acting in one of these ways, although the intestinal contents may escape in conditions of sphincteric incontinence and, under certain conditions, may literally run out or be forced out by pressure, as immediately after enemata, from accumulations of gas in the intestine, external pressure, or extrinsic muscular compression.

However, as contributary causes, must be included changes in the intestinal content as follows: increased irritant nature of the contents due either to an extrinsic drug or poison or to saprophytic decomposition favored by any form of intestinal indigestion, or the inevitable irritant effect of certain normal food ingredients, as cellulose, woody and other dense material, fats, and sugars, either directly or after digestion. Mere bulk of contents, especially in water and gases, must be included as a cause, for a bulky diet usually produces indigestion, excessive gas formation, and production of irritants by decomposition. Increased bulk of contents may be due to diminished absorption or increased secretion or excretion into the bowel. Vasomotor conditions, associated with cardiac and renal disease, due to sudden changes of temperature, etc., whether essentially consisting in general increase of arterial tension, or in local, intestinal, relaxation of arterioles, increase the bulk of water in the bowel. Increase of gaseous pressure may be due to the introduction of aërated beverages, chemicals producing effervescence with other chemicals or the acid of the stomach or alkaline carbonates of the intestine, to aerophagia, etc., possibly to a process similar to internal expiration, to the interaction of the gastric acid with the intestinal carbonates, to the decomposition of cellulose into methane and hydrogen, to various other saprophytic decompositions producing gases or volatile substances. In the so-called lienteric diarrhea, not necessarily confined to infants, in which a passage of the bowels follows almost immediately upon the taking of food, it is scarcely necessary to state that the fecal discharge does not consist of the food just taken but, somewhat after the analogy of a two-cork popgun, the entrance of ingesta, acting upon a fairly uniform column of gas, increases the internal intestinal pressure so that there occurs a stimulation of peristalsis which forces out the contents of the lower bowel. It is not conceivable that the gaseous column is ever so perfect and under such pressure that such an extrusion is literally due to pressure, as in the case of the popgun.

Local lesions of the intestinal wall itself, as ulcer, cancer, inflammatory areas, constriction, intussusception, etc., may also stimulate peristalsis and produce a diarrhea either in connection with or independent of the functional causes mentioned.

Diarrhea may be imitated or, if the term be used in a loose sense, may be said to be caused by the entrance into the intestine of extraneous matter, not referring to the ingestion of more or less foreign indigestible residue or substances supplemental to the diet. A copious hemorrhage, as from gastric or duodenal ulcer or of other origin, is frequently considered by patients as a diarrhea and while the matter of nomenclature is not important, a recognition of this condition, if no other reason existed, demands the routine careful inspection of at least an occasional passage. Any fistula or sinus opening into the bowel may also produce a discharge. Among such discharges may be mentioned urine, as in intentional fistulæ for any reason, products of conception, contents of cysts. In a case observed post mortem by the writer, the gelatinous contents of a large ovarian cyst, which had become adherent to and had ruptured into the colon, were discharged for a week or more before death as vomitus and diarrheal passages, and at necropsy the material was found throughout the intestine and in the stomach. Abscesses and empyemas of various origin may also discharge into the bowel. In all such cases, not only may the discharge of non-fecal matter imitate diarrhea but the essential or secondary saprophytic irritants contained or developing in the discharges may set up a true diarrhea.

Classification.—The underlying physiological and pathological factors considered as causes of diarrhea do not afford a satisfactory basis for clinical classification but are necessarily included in the following suggestive table:

1. *Diarrhea Due to Extrinsic Chemical Irritants.*—A. Frank poisoning by irritants not used as cathartics; arsenic, antimony, copper, zinc, iron, phosphorus, in fact almost any salt of a heavy metal or metalloid and a large number of vegetable irritants may act in this way, with due regard to dose, etc. Colchicum may be mentioned as especially treacherous, since it is frequently employed therapeutically, even by the laity, and since the diarrhea and other symptoms do not increase beyond a certain point, but the cumulative effect may result fatally.

B. More or less gross overdosage of cathartic drugs, especially drastics.

C. Irritation produced by substances of little or no nutritive value but taken as relishes, the irritation not depending upon factors mentioned in the second heading but upon some cathartic principle not uniformly present. Here may be mentioned the occasional violent diarrhea due to cucumbers, and other unripe fruits and vegetables, not explicable by saprophytic changes, mechanical irritation, failure of digestion, etc.

2. *Diarrhea Due to Ordinary Ingesta, the Types Mentioned Being Liable to Association.*—A. Mechanical irritation due to insufficiently masticated food or that especially abounding in indigestible residue and hard and sharp particles. Green apples and other unripe fruit, peanuts, chestnuts, large pits and seeds, bits of bone, etc., deserve especial mention.

B. Undue stimulation of peristalsis by large masses of indigestible residue of a spongy or fibrous nature, mainly consisting of leaves, stalks, etc., of vegetables.

C. Stimulation by excess of fatty matter. The limit of relatively—never anywhere near absolutely—complete fat assimilation may be placed at 150 grams. Beyond this amount, any animal or vegetable fat or oil, either in its original state or split by pancreatic digestion, commences to have an irritant action, even without marked bacterial decomposition.

D. Chemical irritation by products of decomposition, including putrefaction of proteins, marked by the presence of large amounts of indol in the feces and indican in the urine; fermentation of carbohydrates and rancidity of fats and oils. These products may be taken preformed in tainted foods, or may develop in the alimentary canal. While their development is favored by any lack of digestion, they also occur in the absence of conspicuous antecedent indigestion when, for any reason, the intestinal flora becomes especially rich and virulent. Moderate degrees and probably particular forms of protein decomposition are often associated with constipation rather than diarrhea, although, in such cases, the constipation is occasionally interrupted by a state of diarrhea, not entirely due to the direct irritation of scybala. Acute forms of diarrhea are rather more apt to develop from excess in carbohydrates, including starches, sugars, and cellulose; from sugars directly by osmotic action, from cellulose especially on account of the formation of gases as previously mentioned. The term ptomaine poisoning applies particularly to protein decomposition, but the term is often employed loosely and its literal correctness is somewhat in question. Cholera infantum or, in adults, cholera nostras is probably to be included here, though many cases are better explained under A.

3. *Diarrheas due Essentially to Functional Disturbances of the Alimentary Canal and its Tributaries*, the term functional not excluding an ultimate organic cause.—A. Achylia gastrica is, by some, used almost as a synonym of gastrogenic diarrhea. It is frequently accompanied by relaxation of the pylorus so that the food slips quickly through the stomach; and there may also be an analogous relaxation of sphincteric action of the circular muscular fibers of the intestine but without marked atony of the propulsive function of the stomach or intestine, so that a sort of diarrhea occurs. It would naturally be expected that achylia gastrica would be accompanied by marked saprophytic action, with excessive gas production, etc., but this is not necessarily true. But achylia gastrica is not strictly synonymous with gastrogenic diarrhea, since many other forms of gastric lesion and functional disturbance may lead to diarrhea. And, indeed, there are many cases in which achylia gastrica not only does not produce diarrhea but persists with excellent intestinal function, without anemia, and with good general health, for many years.

B. Marked reduction of HCl secretion, from any cause, but without essential failure of ferment secretion, so that the term achylia is not warranted, has the same tendency to result in easy passage of alimentary contents through the stomach and intestine, but subject to the same exceptions as true achylia.

C. Hyperchlorhydria, per contra, tends to produce spasm of the pylorus, and hence ischochymia, and to inhibit bacterial growth in the stomach, though this favorable tendency may be overcome by the delay. The acid may also act as an astringent upon the intestine. Thus, there is a tendency to generalize and to state that gastric subacidity tends toward diarrhea and gastric superacidity toward constipation. But numerous exceptions occur in either case. In particular, the superacid gastric contents may act as a peristaltic stimulant directly instead of as an astringent. While hyperchlorhydria theoretically implies superior gastric digestion and relative antisepsis in the stomach, there is a concomitant inhibition of carbohydrate digestion, a tendency to neutralize the alkalinity necessary to intestinal digestion, and a state of general intestinal indigestion may occur with so much bacterial activity that diarrhea results. Then, too, the carbon dioxide normally formed in moderate quantity by the interaction of acid chyme with the alkaline carbonates of the bile, pancreas, and intestine itself, may be produced in excessive amount, there being probably a concomitant excess of alkaline secretions. Thus the excess of gas in the intestine may unduly favor intestinal evacuation, as already discussed.

In addition to gastric stagnation of the hyperchlorhydric, ischochymic type, atonic stagnation, or that due to organic obstruction, as in pyloric ulcer, cancer, etc., may in various ways disturb intestinal digestion, favor saprophytosis, and lead to diarrhea.

D. As is well known therapeutically, an excess of bile artificially supplied by mouth or by enema, markedly stimulates peristalsis. Hence, theoretically, we may postulate hypercholia as a cause of diarrhea. While in diarrhea, one frequently finds unchanged bile pigments in the feces instead of the normal hydrobilirubin, this may be due merely to lack of time for their subsequent change. Thus, an essential excess of biliary function, as a direct cause of diarrhea, is not demonstrated.

E. On the other hand, while any form of biliary failure or obstruction removes an important factor in the stimulation of peristalsis, so that there is an immediate tendency to constipation, and while bile itself is not directly antiseptic, interference with fat absorption due to lack of biliary salts not only allows a direct stimulation of peristalsis as mentioned under 2, C, but tends to putrefaction and fermentation and consequent diarrhea. However, the stools most typical of biliary obstruction are clay-colored and pasty rather than liquid.

F. Any serious degree of interference with pancreatic secretion or impediment to its discharge into the duodenum prevents the digestion of all three kinds of organic nutriment except as occurs from the action of ptyalin and pepsin, by chemical reactions other than those due to ferments, and by the ferments of bacteria. While this deprivation would be expected to lead to diarrhea from the action of saprophytes, this does not always follow. Achylia gastrica may be associated with achylia pancreatica, notably in Addison's disease, but this association is not regular. When it does occur, the feces show slight digestion, usually considerable decomposition, and the passages are more frequent than normal but not necessarily of an extreme diarrheic type.

G. Whether interference with the essential intestinal secretion, digestive or hormonic, is a practical factor in the causation of diarrhea, is not decided.

H. Vicarious elimination by the intestine in renal disease and somewhat similar conditions of increased elimination of water in states of high arterial tension or in extreme anemia, including leucocythemia, with or without the development of essential indigestion, increased saprophytosis, etc., may result in diarrhea. Such diarrhea is, however, often favored by medication and diet; it is not a constant feature but tends to occur from chilling and physical strain; it is, on the whole, a conservative process.

4. *Diarrheas Due to Organic Lesions of the Alimentary Canal.*—A. Ulcers high in the alimentary canal, that is, mainly in the stomach and duodenum, do not usually produce diarrhea except in the event of copious hemorrhage. Ulcerating cancers or other tumors or granulomatous lesions, more frequently produce diarrhea in the event of small hemorrhages, on account of the tendency to depression of the digestive functions and because the local lesion favors the development of putrefactive bacteria.

B. Ulcers of the small intestine below the duo-

denum or upper part of the jejunum are usually tuberculous or syphilitic or due to some acute specific infection. In such cases the general and digestive depression, constant irritation, and focus of bacterial decomposition usually cause an obstinate diarrhea.

C. Ulcers of the large intestine are commonly supposed to produce diarrhea of the dysenteric type, with frequent but small passages consisting largely of mucopus and blood. But cases occur in which copious, liquid passages of the choleraic type, and with only occult blood, persist for weeks or months and are then promptly relieved by applications through the sigmoidoscope to minute ulcers.

D. Enteritis, using the term in the general sense of acute, subacute, or chronic catarrh of the mucous membrane of any part of the intestine, not due to any recognized specific infection, is usually divided into two types, enteritis proper, involving the small intestine, and colitis, involving the large intestine. But the more closely such cases are studied, the more necessary does it become to recognize the special involvement of varying extents of the intestine so that many hyphenated terms, such as ileotyphlitis, etc., are required unless one contents oneself with the statement that there is an inflammation of the intestine involving such and such parts. Cholera nostras or cholera infantum, arising usually from the irritation of coarse, indigestible, and decomposing foods, assumes by successive gradations the form of a true enteritis. Colitis, on the other hand, imitates a true dysentery, the distinction of terms being arbitrary. However, as diagnostic methods become more refined and are checked by the results of operation, specular treatment, etc., the conception of colitis as a diffuse inflammation of the large intestine is giving place to that of local non-specific infections, minor traumatisms, ulcers, etc., involving especially certain portions of the large intestine, as the cecum, appendix, sigmoid, rectum, etc.; valves, angles, portions of the bowel resting against bony parts, and those in which the contents are longest retained, being more vulnerable than others. In spite of this tendency to localize, any lesion extends more or less in both directions. As in the case of the non-specific choleras, colitis, or "dysentery" in the loose sense, includes a preliminary stage in which the irritation of decomposing contents, hyperemia due to chill, etc., have not reached a true inflammatory status. So-called camp diarrhea or dysentery involves any of these gradations and the chronic forms, of years' duration, formerly so commonly observed in veterans, probably depended upon the establishment of ulcers—an explanation quite compatible with the immediate cures frequently observed after the use of mineral astringents. Subacute camp diarrhea, especially in the past, was also probably often a manifestation of scurvy. In no other way can we explain the prompt relief sometimes afforded by such gross indiscretions as the eating of decayed fruit, cabbage stumps that had been alternately frozen and thawed, etc. Even in civil practice, scurvy is occasionally encountered, not so much on account of poverty as of indifference to food in alcoholics and tobacco chewers, and idiosyncratic dislike of fruit and fresh vegetables.

As is well known, subacute and chronic inflammations of the appendix, cecum, etc., are often associated with, perhaps really due to chronic constipation, or rather to its concomitant opportunity for bacterial activity. But this same process is frequently attended by exacerbations in which the stagnating fecal mass or hard scybala produce an irritative diarrhea.

Inflammatory conditions of the intestine in which mucus is conspicuous or is made the turning point in the diagnosis often produce diarrhea or alternations of diarrhea and constipation. Products of decomposition, notably indol, in such cases produce considerable depression and nervous symptoms of such a degree that the condition is regarded by many as a neurosis—putting the cart before the horse. When much mucus is formed low in the intestine, a dysenteroid diarrhea may occur, though not necessarily accompanied with bleeding. There is a common notion that mucus in visible masses denotes catarrh of the large intestine, while mucus intimately mixed with the feces so as to require very careful macroscopic or even microscopic examination for its detection, arises in the small intestine. While this notion is measurably true, a better conception is that the mucus is no better gauge of intestinal than of respiratory catarrh, but that the more conspicuous it is, the lower is its origin. The character of the mucus varies greatly, from leucocytes and shreds recognizable only by the microscope, through gelatinous or pearly lumps, to abundant slime, and culminating in ribbons or casts. Even the toughest bands and casts consist almost always of mucus and very rarely are true exfoliations of the mucous membrane itself.

E. Parasites. On the one hand, mucus favors the colonization of gross intestinal parasites; on the other hand, the presence of a worm of either the nematode or the cestode type tends to produce a free secretion of mucus, not to mention the possibility of minute ulcerations. Intestinal parasites, in and of themselves, do not cause diarrhea but rather coexist with constipation. However the secondary lesions and interference with digestive functions are rather apt to produce diarrhea. So, too, the slipping away of a worm, with a mass of mucus, is often interpreted by the patient as a diarrheic discharge.

5. *Specific Infections Associated with Diarrhea.*—Here may be mentioned cholera asiatica, amebic and bacillary dysentery, and typhoid fever. Barring hemorrhage, localization of ulcers in the colon, or saprophytic development due to improper diet, as one consisting exclusively of milk or rich in animal broths, typhoid fever is not often attended with diarrhea. There is also usually more or less diarrhea in grave forms of sepsis but perhaps only for the same reasons that it occurs in other prostrating diseases such as leucocythemia, Hodgkin's disease, advanced tuberculosis, syphilis, and malignant disease, even without notable local lesions in the intestine. These conditions will not be considered in detail.

6. *Diarrhea of Nervous Origin.*—This may occur in tabes and various other forms of central or ganglionic lesion, probably from definite stimulation or depression of the respective nervous controlling factors, as discussed under Physiological Considerations. Lack of sphincteric control may also simulate or apparently magnify the indications of diarrhea.

As is well known popularly and expressed in various vulgar metaphors, transient diarrhea may occur from various emotions, notably fright. But, in these functional cases also, the element of sphincteric relaxation is important.

It should be noted that the gauge of diarrhea by fecal evacuations is somewhat fallacious. Sphincteric control varies in different individuals, depends upon nervous impressionability, will-power, and organic health or lesion of the anus and adjacent bowel. The presence of gas in the rectum, or a small mass of mucus, or the remains of a demulcent cathartic, such as agar-agar or petrolatum, or the separation of a soft fecal mass, while not important in comparison with the general condition of the intestine and its contents, may have a marked effect on the number of passages. Nor should it be forgotten that the various conditions naturally leading to diarrhea, but opposed by a strong sphincter reinforced by a strong voluntary control, are, potentially, identical, whether they lead to frequent evacuations or not.

Seasonal Prevalence of Diarrhea.—The term "summer complaint" epitomizes a popular conception

of the seasonable prevalence of diarrhea. Obviously, the greater abundance of laxative fruits and vegetables, the tendency to preexisting bacterial or yeasty contamination of all foods, to infection of foods by flies, the temptation to free indulgence in water, soft drinks, ice-cream, etc., irregularity of meals in the vacation season, subjection to badly prepared foods of inferior grades away from home, the more general use of improperly supervised water-supplies, the tendency to overheating and subsequent chilling, are all more frequently operative during the warm weather. Fortunately, in the last few years, the sanitary control of water and foods, more general insistance on refrigeration, and popular education have so far reduced the frequency of summer diarrhea that it is no longer regarded as inevitable but is regarded as a matter for prompt treatment and investigation as to cause in order to prevent its further occurrence. The control of the milk-supply, the provision of pasteurized milk for the poor, and the elimination of the long tube of the nursing bottles have correspondingly reduced the frequency of cholera infantum.

The term winter diarrhea probably originally alluded to more or less marked cases of scurvy due to deprivation of fresh fruits and vegetables, and to the almost inevitable exposure to tainted foods before preservative methods, including refrigeration, were perfected. In many localities, also, the term undoubtedly denoted a restriction of water-supply on account of freezing, so that more highly contaminated water was used. In such cases, it tended to coincide with epidemics of typhoid fever, involving many with colon bacillus, paracolon, paratyphoid, or other intestinal infection, who were, by the law of chance or by previously acquired immunity, not infected with typhoid. In other instances, the agitation of lake-water by storms perhaps justifies the term "sand diarrhea." It is possible that the minute but macroscopic cyclops or diatoms or other animalcules more common in winter than in summer, may have a directly pathogenic influence.

In individual cases, seasonal diarrhea is due simply to the seasonal abundance of some form of food, as berries, grapes, watermelon, cucumbers, etc., or to social habits involving greater and more numerous dietetic indiscretions at certain times. Wherever considerable numbers of persons are fed according to the same schedule, irregularly cyclic exacerbations of diarrhea may be expected. Picnics, corn-roasts, clambakes, etc., may be noted. Lemons, onions, crustacea, strawberries and other foods liable to produce idiosyncratic diarrhea, even when served in quantities apparently too small to be appreciable, almost always cause a number of cases of diarrhea at camps, and in institutions where many are fed from the same general supply. There is scarcely any food which does not have an idiosyncratic influence on a few persons. This has been explained on the ground of anaphylaxis, but the question then follows why the anaphylaxis is so irregular in its occurrence.

Many local or group epidemics are due to tyrotoxicon developing under the influence of the colon bacillus in milk and its products. Others are due to the accidental tainting of some particular article of food, as in a hospital-epidemic traced to oatmeal into which plaster had fallen from the ceiling, carrying with it various saprophytic bacteria. The outbreak in a hospital of a number of cases of paratyphoid, reported recently by the U. S. Public Health Service, was traced to a kitchen helper but without determining any definite hygienic flaw or any particular means of conveyance. At times, the diarrhea may be due to gross poisoning; purely accidental, as by mistaking some poisonous powder for one of the many substances used in cooking; on account of adulteration, as in the chrome-yellow cases noted in Philadelphia some years ago, in which the lead salt was employed fraudulently to color cakes and frostings, but without homicidal intent; as in other cases in which some drug is used to produce discomfort as a joke, in revenge, etc., or with direct homicidal or suicidal intent, with concealment of motive and means employed.

Diagnosis.—So far as the applicability of the term diarrhea is concerned, the diagnosis should be easy, but lack of discrimination and misuse of terms on the part of the laity are quite common, so that the physician should at least inspect an occasional passage. Otherwise, the most unaccountable inaccuracies will occur.

Without attempting a table of differential diagnosis or reviewing the subject of coprology or the general diagnostic methods applicable to all cases, these methods, in connection with the consideration of possible causes as already tabulated, will usually assign a case to one of the following groups:

1. Diarrhea symptomatic of a general specific infection. (See *Cholera*, *Dysentery*, etc.)

2. Group epidemics or sporadic cases due to a particular strain or mixture of strains of bacteria not ordinarily classified as producing specific infections—although the distinction is somewhat arbitrary. Here may be mentioned paratyphoid, paracolon, ordinary colon bacillus, *Bacillus aerogenes capsulatus*, and various other bacteria found in the intestine.

3. Extrinsic poisoning, homicidal, suicidal, accidental, due to adulteration of food stuffs; by-effects of drugs not used as cathartics, overdosage with cathartics or use of cathartics in ignorance of their logical effect.

4. Diarrhea secondary to cardiac, renal, vascular, and essential blood lesions, the diarrhea in these cases being often conservative.

5. Cases in which the diarrhea consists essentially of a discharge of blood, pus, products of local inflammation, ulcers, neoplasms, etc.

6. Cases in which the diagnosis rests mainly on thorough investigation of digestive processes, dietetic causes, and secondary saprophytic changes, the diarrhea being mainly functional so far as the intestine is concerned but often due to organic lesion of tributory organs, such as the stomach, liver, and pancreas.

7. Cases in which the general examination is of importance negatively or as pointing to some contributary organic cause outside the intestine, and in which the fecal and local examination (including palpation of the appendix, etc., and use of specula) is of importance in demonstrating organic lesions rather than functional disturbances of the intestine.

Prognosis.—While it is obviously impossible to make any positive general statement, considering the wide variety of causes upon which diarrhea may depend, the following facts are important: In and of itself, a diarrhea is not fatal, unless of such degree, nature, and duration as to interfere with nutrition. In such cases, it is usually not the diarrhea itself, but some pancreatic lesion on which it depends, that makes the condition serious. The depression accompanying diarrhea may, however, be fatal at either extreme of life and may be the last straw in tuberculosis, cancer, etc., as well as in acute infections characterized by diarrhea. A diarrhea not due to an organic state of practically irremediable nature or to an overwhelming acute infection can almost always be controlled but it is not usually wise to do so except as the underlying condition is itself controlled. A diarrhea not depending upon inevitably and obviously irremovable causes, as malignant disease, organic achylia pancreatica, etc., can almost always be cured, either by operation, specular treatment, or appropriate medication, diet, etc.

Treatment.—In close analogy with antipyretics, we possess a considerable number of astringent

drugs which can overcome the symptom of diarrhea unless the antagonistic stimulation of catharsis is of undue degree. But, likewise in analogy with antipyretics, such medication is not merely palliative but usually reprehensible. However, the view that a diarrhea is a conservative process, eliminating toxins, and never to be stopped directly, is extreme. Such astringents as tannin or its modifications, hydrastin, bismuth salts, sulphuric acid, etc., often have a favorable action on a functional disturbance or organic lesion. The feces inevitably contain both endogenic and exogenic—bacterial—toxins, and it is going too far to claim that the process of elimination should never be delayed so as to conform to normal standards. Both in acute diarrheas, such as that of Asiatic cholera, and in chronic forms the prostration due to the excessive evacuations may be dangerous and, granting that the preliminary "clearing out" has taken place, either as the result of calomel, followed by a saline or castor oil, of castor oil or other cathartic alone, or spontaneously, and that an exhausting diarrhea continues, it is usually good policy to employ the chalk mixture, bismuth, some vegetable astringent, etc., with the idea of checking the discharges. In fact, the preliminary catharsis, probably in general best effected by castor oil, is applicable especially to cases of obvious dietetic origin. The empty intestine has been shown experimentally to have a marked tendency toward self-sterilization. Hence, it is a good rule to give no food and as little water as possible for at least a day or two after the beginning of a diarrhea, if the condition is of any degree of severity. Even when prostration is great and the indication for nourishment pressing, it is doubtful whether enough nutriment can be digested and absorbed to counterbalance the depression of diarrhea in the first day or two. Following this, the food should be as simple and easily digestible and should contain as little residue as possible. Boiled milk, toast, or some fine cereal without bran or chaff, with tea, on account of its astringent action, instead of water, should usually be the diet for the first few days after feeding is resumed. The milk may be peptonized or partially digested by the addition of hydrochloric acid, drop by drop (about 3 c.c. of the officinal dilute acid to each 100 c.c. of milk), although it is somewhat doubtful whether such digestion really accomplishes much. Nutrient enemata are usually out of the question. Eggs, as in omelette or combined with milk in custards, scraped meat broiled on a hot dish, a variety of bread stuffs and cereals, gelatin preparations, particularly indicated in hemorrhage, comprise the main portion of the subsequent diet, gradually returning to the ordinary food. It is important to control the diet by an examination of the digestive processes, including analysis of the feces, and to distinguish between conditions in which the decomposition of proteins or the fermentation of carbohydrates or rancid decomposition of fats is the principal element.

Pathological discharges, notably of blood, present the same indication for elimination to prevent the effects of toxins produced by bacteria as do decomposing remnants of food. But this indication is counterbalanced by the danger of exciting fresh hemorrhage or exacerbating some other pathological process—as for instance in the appendix. Hence, the opposing indications should be carefully weighed and catharsis should be produced, when necessary, by mild measures, notably by lavage from below.

In a sudden and severe diarrhea, without obvious dietetic explanation and when the occurrence of a specific infection is improbable, gross poisoning of one of the types mentioned should be suspected, prompt analyses should be instituted, the ordinary medico-legal precautions should be taken, and appropriate treatment should be carried out, often in advance of chemical reports.

The number of passages can frequently be reduced by clearing out vestiges of irritating nature which cause tenesmus and partial movements. Injections of one-half to one per cent. of boric acid in 6 per mille salt solution may be used, usually lukewarm or cool. Sometimes, small injections of laudanum in starch water or anodyne suppositories are required. A distressing and even serious complication of diarrhea is the local irritation caused not only by the various products of decomposition in fecal matter and pathological discharges, but by the pancreatic ferments which, owing to the hasty passage through the intestine, are still in an active state. Applications of vaseline to the anus or injections of 100 to 200 c.c. of pure mineral oil, perhaps containing salol, camphor, etc. in solution, or bismuth in suspension, may be employed to prevent direct contact with the mucous and mucocutaneous membranes.

While water is theoretically indicated to make good the deficit due to abstraction by the copious passages, it should be considered whether the elimination is not a conservative process, to reduce high blood-pressure, or as part of a vicarious action for the kidneys, or to remove pathological deposits of liquid. Even if none of these factors exists, a free supply of water facilitates further bowel movement. Hence, thirst should usually be combated by holding water in the mouth or allowing the swallowing of very small quantities, sometimes even by administering opiates. Ice relieves thirst only temporarily and, if long used, is apt to cause stomatitis. Small drafts of hot tea often relieve thirst and act as an astringent. If water is to be supplied, it is usually best given by enema or by hypodermoclysis.

In acute forms of diarrhea and in those alternating with states of constipation, also in certain cases of more chronic diarrhea, the existence of surgical lesions should be considered. Among these may be mentioned intussusception, septic inflammation of the appendix, gastric and duodenal ulcer, various lesions of the biliary passages and pancreas.

When the passages are of the dysenteric type, the local measures already mentioned are especially appropriate.

In chronic forms of diarrhea, even when the discharges approach the choleraic type, and even when blood, if present, is of the occult form, the lower bowel should be inspected by specula, at least a foot of its extent being thus accessible. Any lesions present should have appropriate treatment. Even the application or injection of solutions of protargol, etc., or, in the past, of the cruder astringent metallic salts, copper, zinc, and silver, often produces prompt relief.

A. L. Benedict.

**Diarrhea, Infantile.**—Diarrhea is the symptom produced in infants by the upsetting or derangement of the normal functional balance of the intestines, and is manifested by increased peristaltic and secretory action resulting in frequent loose, often watery evacuations of the bowel. It is never to be considered a disease entity; it may be but one of the many symptoms of different morbid states, or the result of other pathological conditions and is nature's effort to rid the system of offending substances or poisons.

Occurrence and Prevalence.—It is one of the commonest and most important pathological conditions found in children in the temperate zone, where the variability of temperature and extremes of humidity, especially in the summer and autumn months, seem to be strong contributing factors in its development.

A study of the statistics of mortality from diarrheal disease in infants under two years of age in the United States for the years 1907 to 1910 show interesting results. While the death rate averages about the same all over the United States, along the Pacific coast it is lower, due to the equable climate which

seems to have a favorable restraining influence over this condition. In the Middle States, the rate is increased, and becomes greatest along the eastern coast. There is no great difference between the Northern and Southern States, but the Western States show a much lower rate. The mortality in the country districts is usually less than in cities, while apparently increased in the manufacturing cities. While diarrhea in infants may occur at all seasons, the greatest mortality rate is usually during July and August. In some years, more cases have been reported in a cold spell in September following a hot August, than during the height of the hot season, but this has probably been due to secondary infections. Still reports the average yearly deaths in London to be 16,000 in children under one year of age; of this number 2,000 to 4,000 are from diarrheal conditions. Budin of Paris and Finkelstein of Berlin speak of the prevalence of diarrhea of a mild type in those cities. Baker gives the deaths in New York City for 1912 as over 9,000; of this number about 2,200 are from diarrheal diseases in babies under a year old.

General Causes.—The causes of infantile diarrhea have been a source of much divison of opinion among pediatrists for many years. Even now, when apparently new theories have been advanced and attempts made to prove them, it will be seen that after all they are but the best of the theories of the early days of pediatrics applied to improved clinical observations.

Since diarrhea is a symptom of many conditions, it is impossible to attribute it to any one etiological factor, but it should be considered rather as the result of a combination of factors, which working together, produce it.

During the first two years of child life, and even more so in the first year, one function is highly developed and in constant demand, the absorption of food for the great process of growth. The alimentary tract therefore is naturally the part in which any physical derangement would most readily find expression. Add to this any inherited or acquired physical condition, such as syphilis, chronic indigestion, or marasmus, and a weakened constitution and lowered vitality are produced rendering the digestive tract more susceptible to external influences and less able to withstand them.

While diarrhea occurs all through the year, it is much more prevalent during the summer, the season of intense and variable climatic conditions. Many contend that the direct influence of the excessive heat produces diarrhea, while others attribute it to the increased humidity. Liefmann and Lindemann, after exhaustive researches covering a period of fifteen years, show that in Berlin the death curve and also the sick curve are almost exactly parallel with the curve of the daily 2 P. M. atmospheric temperature. Observations have been made in cities all over the United States with reference to the mortality rate and the heat and humidity. At one of the children's hospitals in New York in the summer of 1913 it was observed that the number of deaths from gastro-intestinal conditions was greater after a sudden change in the weather from extreme heat to cool temperature, and not during a continued period of hot weather. Diarrhea is not as frequently found in the country districts as in the cities where, especially among the poor, six to ten persons may live in one room. The crowding together of so many people in a small space raises the temperature in the houses from five to ten degrees higher than that of the street and also increases the humidity. This allows of less bodily radiation of heat in the tenement-house baby, consequently raising his temperature and lowering his resistance. In addition to this, the unhygienic surroundings, lack of frequent bathing, and the accompanying filth, from which germs may be transmitted by flies and other vermin, all make ideal factors in the production of diarrhea. Ignorance—national, municipal, and maternal—of the proper care of infant life, has much to do in the promotion of this condition. Fortunately, public interest is now sufficiently aroused and the baby may yet come to his own from the right sources.

Diarrhea is often a symptom of the contagious and infectious diseases, and the result of the action of certain drugs such as cathartics, antimony, and corrosive sublimate. It is produced reflexly through not only heat, but chilling of the body surface, fright, exhaustion, and, some writers claim, from dentition. It is often the first symptom of otitis media, but whether it is a nervous reflex or a continuation of the ear infection has not yet been determined; it is probably the latter.

The germ theory has already been discussed. There is probably little doubt that the severe forms of diarrhea may be increased in virulence through the direct or indirect action of bacteria and their toxins, either already in the intestines or introduced from without.

While these factors contribute largely toward the production of diarrhea, the main factor which allows the action of these predisposing causes is found in the food of the baby, or the milk it receives.

Diarrhea is not as frequently found in breast-fed as in bottle-fed babies. Breast-fed babies, especially up to three months of age, are rarely subject to it, for maternal conditions prevent it.

Cameron has shown that in summer, mothers, among the rest of humanity, drink more fluids, and this tends to thin the breast milk, thus acting as a preventive to indigestion in the infant by reducing the proportion of solids in the milk. Also, that babies, when affected by the summer heat, refuse to suck as long at the breast, which is an additional prevention. Bottle-fed babies do the opposite, as a rule, for they are fed more frequently on account of their fretfulness. Colostrum sometimes produces a slight diarrhea in new-born infants. It is, however, in the artificially fed babies that the enormous number of cases of diarrhea, especially of the so-called "summer" type occurs. This is largely due to the improper modification of the milk, over-feeding, and irregular feeding. These all increase indigestion, allowing fermentation and putrefaction to take place in the intestines, the food acts as an irritant, or toxins are absorbed, and diarrhea with accompanying symptoms is set up. Impurities in milk, caused by long transportation in the heat allowing the growth of bacteria in greater numbers than the intestinal tract can withstand, and the introduction of new germs through dirt, readily induce diarrhea.

Each constituent of the cow's milk—fat, sugar, and protein—if in proportions unsuited to the digestive apparatus of the individual child, may induce disturbances which result in diarrhea.

Biedert showed long ago that the fats were the first disturbing element, producing constipation and later diarrhea. Jacobi demonstrated that the sugar of cow's milk causes fermentation and diarrhea. Finkelstein, Meyer, and others take the same view, but go further and claim that the proteins practically never cause indigestion. The Czerny school also hold the same principle, but consider protein dilution as easier of assimilation. Holt has shown that a too high percentage of protein (casein) can give rise to alimentary fever and intestinal disturbance. Carbohydrates as a class, whether in the form of cereal gruels, malt soup extract, or any of the malt sugars, when improperly fed to infants can produce intestinal fermentation and diarrhea. Hess has shown that lipase is deficient in acute intestinal disorders, and Harrower points out that the production of secretin is likewise reduced in cases of acute intestinal disease.

Thus it will be seen that many factors play a part in the causation of diarrhea, but in what proportion we can expect them to act will depend on the personal equation of each individual baby.

Bacteriology.—It has long been an open question whether the flora found in the stools from infantile diarrhea have any direct bearing on the cause of the condition. Scientific investigations have not proved yet that any certain organism produces definite results or types of diarrhea, since the same clinical picture has been found, in both the presence and the absence of pathological organisms, and the same organisms have been present in the mild as well as in the severe forms of this condition. Enough has been demonstrated to show that in a great number of the severe forms organisms are present which are not found in the stools of normal children.

As far back as 1888, Chantemesse and Widal described a bacillus resembling *B. dysenteriæ*. Similar reports were made from different parts of Europe, and later from America. In 1897 Shiga reported the presence of a bacillus, before unidentified, in the stools during an epidemic of dysentery in Japan. In 1900 Flexner described a similar bacillus in association with an epidemic of dysentery in Manila. Later investigations have shown that the Shiga bacillus is found more frequently in the stools of the severe or dysenteric type of diarrhea, while the Flexner bacillus is present in the milder types.

Booker in his studies of infantile diarrhea divided his cases into two groups one, the mild type, associated with the *B. proteus vulgaris;* and the other, or severe type, due to the presence of the streptococci. He did not claim these germs as the cause of these types of diarrhea, but only that they were in association with them. Janowski concluded that no one organism was the cause of diarrhea.

During the summer of 1903, the Rockefeller Institute directed an investigation in Boston, New York, Philadelphia, and Baltimore in order to determine the relation between *B. dysenteriæ* and summer diarrhea. A total of 412 cases of infantile diarrhea were studied and of these, 279, or 63.2 per cent. showed the presence of some type of *B. dysenteriæ*. The summer before (1902) Duval and Bassett in Baltimore found *B. dysenteriæ* in forty-two out of fifty-three cases of infantile diarrhea. This organism has been divided into two main groups, depending on its reaction to litmus mannite. The first, or alkaline group, is represented by the Shiga bacillus; the second, or acid group, by the Flexner type. Park, Castellani, and others have called the Shiga group by the term "paradysentery," on account of the severity of the symptoms usually seen in cases of diarrhea, where this type of organism has been found. According to Holt, the acid or Flexner type is the one most frequently described as found in the stools of cases of infantile diarrhea in this country.

During 1902 and 1903 Wollestein found the organism in thirty-nine out of 114 cases of infantile diarrhea in which she examined the stools from the wards of the Babies' Hospital and the New York Infant Asylum. Morgan in England found a bacillus in the diarrheal discharges of infants, which resembled the hog cholera organism of MacFadyean, but in no case did he find a bacillus related to either the Flexner or Shiga types. In France both the Shiga and the Flexner types have been found, but in many of their cases neither organism was present. Tissier has shown that in fermental diarrheas, an organism called *B. perfringens* is present, which replaces *B. bifidus*, the organism found in health. Little credence is given in Germany to the bactericidal origin of infantile diarrhea. They admit the possibility of such an origin, but believe it to be of rare occurrence, attributing diarrhea in infants to chemical or metabolic changes taking place in the intestines. It might be stated in passing, that the dysenteric type of diarrhea with mucus, blood, and false membrane in the stools and intestines is seldom found in Germany.

Kendall, in his investigations, found what he terms a "putrefactive group" of organisms, consisting of a combination of *B. dysenteriæ*, *B. coli*, and streptococci, which produces putrefactive decomposition in certain sugar-free media. He claims that on the addition of sugar to the media, fermentative substances are produced, which inhibit the growth of the putrefactive organisms, thus preventing putrefaction and allaying the diarrhea. He advocates treatment by sugar solution in cases of what he terms "bacillary dysentery," in order to increase the growth of the fermentative organisms, and cure the diarrhea. During the summer of 1910 and again in 1912, he found the gas bacillus the predominating pathogenic organism in many cases of infantile diarrhea.

In 1911, Veeder, Kilduffe, and Denny conducted a study of the flora from the stools of eighty cases of infantile diarrhea in the wards of the Babies' Hospital in Philadelphia. In all, 167 examinations of stools were made, and *B. dysenteriæ* was found in about twenty per cent. of the cases, while the streptococcus was present in eighty per cent. They concluded that the mere presence of a few dysentery organisms in the stools in cases of infantile diarrhea does not prove that the organism in itself is the cause of the condition; often it may be a secondary infection, and streptococci may or may not have a direct bearing on the etiology of the disease; also, there are no clinical symptoms by which cases of gastroenteritis and ileocolitis, in which *B. dysenteriæ* is present can be distinguished from those in which it is absent.

Attempts have been made to isolate the organisms associated with diarrhea from the stools of healthy infants. Duval reported the presence of the Flexner organism in the stools of two normal infants, while Wollstein found *B. dysenteriæ* in the stools in three out of twenty-four infants who died of other conditions, but none in the stools of fifty-six normal babies. Kendall and his staff at the Boston Floating Hospital in 1911 for the first time isolated the Shiga bacillus from the blood.

From the foregoing account, it may be conceded that in the majority of cases of infantile diarrhea of the severe type, either a pure or mixed variety of organisms is present a sufficient number of times to allow the term infectious diarrhea to be applied to that type.

Pathology.—*Gastrointestinal Indigestion.*—The lesions are variable and not marked. There may be a slight general congestion or it may be in patches and there may or may not be a small amount of mucus in the stomach and intestines.

*Gastrointestinal Intoxications.*—The pathology could be briefly described as a superficial catarrhal inflammation affecting the entire gastrointestinal tract. Usually the stomach, the lower ileum, and the colon suffer the most, the duodenum and the jejunum the least. The macroscopic lesions are variable. Throughout the gastrointestinal tract the mucous membranes may be intensely congested generally or this congestion may be limited to scattered patches. As a rule the stomach is distended with gas and contains undigested food. The upper part of the small intestine is empty and the lower portion contains yellow, gray, or green material which is often offensive. The transverse colon, the cecum, and the sigmoid flexure are apt to be distended with gas and contain fecal material, while the rest of the large intestine is empty, its walls being contracted and often covered with mucus.

The microscopical findings are essentially degeneration of the epithelium of the stomach and intestines. Sometimes the epithelium is entirely destroyed.

The bacteria are found in the epithelium and upper portion of the crypts of Lieberkühn and occasionally in the deeper tissues when the epithelium has been destroyed. The changes about the blood-vessels are variable. The vessels may be distended, with hemorrhages or an exudation of leucocytes in this region of distention. The lesions in organs outside the gastrointestinal tract are not marked. They are often accidental although sometimes there are degenerative changes due to toxins absorbed from the intestines.

*Cholera Infantum.*—Sometimes there are no lesions and then the small intestines and colon are distended with gas and contain a thin grayish material, which, as a rule, is not offensive in odor. The mucous membrane is usually pale, although there may be areas of congestion in the colon. Very often cholera infantum succeeds some other pathological process in the intestines and in these cases old ulcerations may be found or chronically inflamed lymph nodules and thickened intestinal walls.

*Acute Enterocolitis* or *Ileocolitis.*—The lesions are varied but their position is fairly constant. The lower two or three feet of the ileum and the entire colon are affected, although in about fifty per cent. of the cases the ileum was apparently normal and only the colon showed marked changes. The lesions may be roughly divided into catarrhal inflammation, catarrhal inflammation with ulceration, and membranous inflammation.

The macroscopic findings are usually confined to the lower ileum and colon although often the stomach may be dilated or contracted and contain mucus and undigested food. The mucous membrane may be pale or it may show areas of marked congestion. The small intestine is usually distended with gas and its contents are green in color and thin. The mucous membrane shows much swelling and edema and is often coated with mucus. Also there is always much congestion, which may be general or in scattered areas and which may be intense enough to produce areas of hemorrhage. The colon is usually empty and its mucous membrane much swollen, the lymph nodules showing edema and congestion as a rule.

The microscopical findings are loss of the epithelium and a thick layer of mucus and round cells along the surface. The lymph nodules of the colon are greatly swollen, chiefly due to an increased number of lymphoid cells. These nodules may, however, break down and ulcerate. Bacteria, usually *B. dysenteriæ*, are found in numbers throughout the mucosa, varying in their depth of penetration according to the severity of the lesion.

Where there is inflammation with ulceration the ulcers are usually confined to the colon, although a few ulcers may be found in the lower ileum. The lymph nodes are the seats of the ulcers, and but rarely a Peyer's patch shows ulceration. The ulcers may be single or several of them may coalesce and thus form very large ulcers. They very rarely extend deeper than the circular muscle coat.

The microscopical findings show that the lymph nodes break down from the summit toward the base, and that there is a marked infiltration of round cells with a simple necrosis.

The membranous form of inflammation is by far the most severe. The macroscopic findings are a much thickened and rigid intestinal wall, affecting only the colon and lower ileum, with the most severe changes about the ileocecal valve or in the sigmoid flexure and the rectum. When there is a membrane, it is of a yellowish or grayish-green color. Where there is no pseudomembrane the surface is very granular and red.

Microscopically there is an exudate of fibrin which forms a distinct pseudomembrane, and in this fibrin there are many round cells and bacteria. The mucosa and submucosa are crowded with an infiltration of round cells so that often the follicles are entirely destroyed. The blood-vessels are enormously distended, with frequent hemorrhagic areas about them.

The most important lesions associated with enterocolitis are bronchopneumonia and acute renal degeneration. The bronchopneumonia may be caused by toxins absorbed from the intestines, though this is doubtful, while the kidney affection is probably due to the irritating toxins absorbed.

In *chronic enterocolitis* or dysentery, the mucous membrane is usually a grayish color and the solitary lymph nodules may show pigmentation.

There is a marked cell proliferation in the mucosa and the solitary lymph nodules show cell hyperplasia. Many of the tubular glands and villi of the small intestine disappear. The lesions are not generally uniform but occur in patches. There may be ulcers present which are of the follicular variety. Some of the ulcers may be new and spreading, while others show signs of cicatrization.

The more common pathological processes associated with chronic enterocolitis are hypostatic congestion of the lungs, a fatty liver, and degeneration of the kidneys.

Acute Diarrhea.—*Gastrointestinal Indigestion.*—This condition may be found in all classes of children and at any time of year. It is usually produced by some defect in feeding. In older children, food too coarse to be digested, the lack of thorough mastication, or the overfeeding with any particular food of which the child is fond, is sufficient to cause an attack. Nervous influences may manifest themselves in this form of diarrhea, and eliminative diarrheas, due to the presence of toxins circulating in the blood from insufficient action of other eliminative organs, are of this type.

*Symptoms.*—When the attack comes on suddenly there may be vomiting, but in the milder more gradual attacks it is sometimes absent. Pain is present as shown by the sharp cries and drawing up of the legs on the abdomen to relieve the colic. It usually precedes the diarrhea by several hours in older children. Diarrhea is indicated by the number of loose stools, which may be from four to eight or ten a day. At first, they are fecal in character, but later become thinner and frothy. In babies especially, the color of the stools changes from yellow to green, due to the presence of biliverdin, and contain pieces of undigested food; if the case is prolonged, mucus may be found. It would naturally follow that in infants the stools would show curds, either protein or fat, and some mucus. Blood is not present. The stools give an acid reaction and a sour odor.

The constitutional symptoms are shown either in mild cases by restlessness, or in severe cases by stupor and convulsions; fever, from 101° or 102° F. to 105° F., may be present in the more severe attacks, or in the mildest attacks it may be absent; the pulse may be rapid and feeble, and prostration may be severe enough to threaten life. If nature or medical aid removes the offending substances quickly enough, the attack terminates favorably, but in delicate children an attack may be severe enough to cause loss of life.

*Gastrointestinal Intoxication.*—Synonyms: Summer diarrhea, gastroenteritis, cholera infantum, fermental diarrhea.

This is the form of diarrhea occurring regularly in summer, which causes such havoc among bottle-fed babies. It may occur in epidemics or in single cases, and is caused by any of the factors producing indigestion, largely influenced by the predisposing causes, heat, bad surroundings, impure milk, and faulty feeding. It is in this type of acute indigestion that the poisons are formed in the intestine, and absorbed into the blood, producing such severe attacks and loss of life. It is still an undecided question to what extent organisms produce fermentation and putrefaction in

gastrointestinal intoxications. They may or may not be present in the stools, but the following types have been found sufficiently frequently to warrant their being considered causes of the intoxication: Kendall's gas bacillus, the *B. perfringens* of Tissier, *Proteus vulgaris*, *B. coli*, and streptococci. *B. dysenteriæ* has also been found in this type, but not so frequently as the others. Kendall and Tissier claim that the gas bacillus and the *B. perfringens* produce fermentation in food already chemically changed in the intestines, especially the proteins, and the process of putrefaction may follow the action of the *B. coli* and streptococci. The Gaertner bacillus has been shown also to produce putrefaction. When recovery takes place, the *B. perfringens* is replaced by the increase of the *B. bifidus*, a normal inhabitant of the intestine.

*Symptoms.*—These resemble very much the symptoms found in the acute indigestions. The attack may begin suddenly in a previously healthy child, or come on gradually. It is usually induced in children, however, who are susceptible to gastroenteric conditions. Vomiting may usher in an attack and persist throughout, or it may be absent. Undigested food, which may have been retained in the stomach for several hours after feeding, is brought up, and if the vomiting persists bile, mucus, and serum may be ejected. Colic is a constant symptom. Diarrhea occurs later in the attack, sometimes twenty-four hours after the onset of the illness, and is accompanied by the discharge of great amounts of flatus. At first the stools are fecal, but after about forty-eight hours, become almost entirely fluid and semiserous in character. The stools go through the changes in color and have a very offensive odor, which is characteristic of this form of diarrhea.

The constitutional symptoms are marked. The temperature may rise rapidly to 102° F. or even higher; restlessness or stupor and convulsions are present. The skin becomes hot and dry; the tongue is coated, but later becomes red and dry. The child refuses to eat, but thirst is excessive. The abdomen is swollen and tender. The symptoms persist for three or four days, then gradually lessen; the stools assume their normal type as food is retained and the patient recovers. Or the symptoms may become worse, prostration is profound, and the little life goes out. The great amount of flatus, the colicky pains, and the foul odor of the stools are characteristic of this form of diarrhea.

*Cholera Infantum.*—All pediatrists seem to agree that this is an unwise and needless division of the intoxications, but it is so commonly known by this name, that it is given here. It is about the most uncommon form of diarrhea, and one might say occurs practically only in the bottle-fed baby. While bacteria have been found in the stools of these cases, the true cause is in the milk—the poisons which it contains—either before or after entering the intestinal canal. It is not known whether the poison is formed by chemical changes or the action of bacteria, but more probably by chemical action. The toxic elements are absorbed into the blood stream so rapidly, and produce symptoms so quickly, that in five or six hours after the onset the patient may be almost moribund.

The *symptoms* are those of the foregoing group intensified. Vomiting and purging are almost constant throughout the attack. There is rapid and considerable loss of flesh; the child becomes pale; the eyes are sunken; tongue coated, but later red and dry; skin cool and clammy, and the abdomen, unlike the previous conditions, is sunken instead of distended. The temperature rises rapidly to 102°–103° F. and in fatal cases to 107° F. High temperature throughout an attack is indicative of a fatal termination. The pulse is very rapid and weak, the breathing shallow and fast, the thirst is intense, while the urine is almost suppressed. Diarrhea is marked, and the stools quickly assume a serous character, which is typical of this form. They may be from eighteen to twenty a day, and at first are acid, but when serous in type become alkaline and colorless. They are usually odorless, but may be putrid.

In this type of diarrhea, the nervous symptoms are most marked. The child is exceedingly restless, tossing about on the bed, moaning, and passing into convulsions with delirium or else falling into stupor and coma. In some cases, the nervous symptoms are more prominent than the gastrointestinal ones, and may suggest meningeal conditions. It is rarely that such conditions are set up.

A case of cholera infantum must show marked improvement in forty-eight to seventy-two hours or terminate fatally, as the symptoms produced are too profound to be longer combated by the physical constitution.

The most characteristic symptoms of this condition are the violent vomiting and purging, the serous condition of the stools, the rapid loss of weight, and the profoundness of the nervous symptoms.

*Acute Infectious Diarrhea.*—Enterocolitis, Ileocolitis, Dysentery.

This type of diarrhea is rather more common in the fall, and is found in children who have had their resistance lowered by previous gastrointestinal attacks during the summer, or ofttimes following bronchopneumonia or the exanthemata. It usually presents far more serious conditions than the foregoing types of diarrhea, where the disease is produced primarily by some change in the food. In this form of diarrhea, anatomical lesions are present, which do not exist in the other types. According to the type of the lesion, enterocolitis is usually separated into three groups: the acute catarrhal form; the ulcerative inflammatory form; and the pseudomembranous form. As the name shows, the seat of the inflammatory processes is in the ileum and colon.

All the predisposing causes which are productive of the other types of diarrhea are equally active in this type, but study and investigation have shown that some form of the *B. dysenteriæ* is found so often in this type that it is to be considered the most active cause. The Shiga bacillus and the Flexner bacillus are the most commonly found both in the stools, and in the walls of the intestines at autopsy. Streptococci are also found in the stools from these cases.

*Symptoms.*—In the catarrhal and membranous forms, the onset is sudden, but in the inflammatory ulcerative type it may be either gradual or sudden. There are usually vomiting for the first twenty-four hours, pain in the abdomen, high fever, 102°–105° F., diarrhea, and prostration. The catarrhal form shows symptoms of acute indigestion, and the stools are of the same type, but as the case progresses, they contain much mucus, which is usually streaked with blood. Rarely is the blood found in clots. The mucus is clear later, and resembles somewhat egg-albumin. Prostration and loss of weight are marked. The ulcerative type is usually grafted on the foregoing one, and after the first day the temperature ranges from 99°–101°. The stools contain much more mucus than in the previous type, but little blood. They range in color from green to brown and in many cases are of an offensive odor. They are not very frequent and only fluid in exacerbated cases. There are steady and increased prostration and loss in weight, and in protracted cases the patient shows all the signs of emaciation. Excoriations of the skin seem to be more common in this form than in the others, due to the emaciated condition and the prolonging of the symptoms. The membranous variety has all the symptoms of sudden onset, with vomiting, high fever, and diarrhea. The stools are thin, of a green or yellow color, and usually contain not only a considerable amount of blood, but shreds of pseudo-

membrane, although blood and mucus are not always present. Tenesmus and prolapse of the rectum are present, and in such cases patches of pseudomembrane may be seen on the mucous membrane of the rectum. One of the characteristic features of this form may be the marked cerebral symptoms, which develop at the onset, and may completely obscure the intestinal symptoms for several days. Sometimes it is only when the membrane can be detected in the rectum or the stools that a correct diagnosis is made. Prostration and loss of weight are progressive.

Enterocolitis may last over a few days in the milder type and recovery takes place, though usually very slowly; or it may progress to the ulcerative type, and then recover. In all the forms of this type the outcome may be very uncertain; apparent convalescence is often marked by relapses, and after weeks of prolonged illness the child may die from exhaustion. The severe types of diarrhea are often accompanied by conditions showing an inflammatory process in the kidneys.

Complications.—The conditions which are more often associated with infantile diarrhea are those usually due to irritation, toxemia, and bacteria. Thrush, not only in the mouth, but extending into the esophagus, is found, especially in cases of the prolonged types. Otitis media is a far more common complication than is generally supposed. It is well, in every case of diarrhea, to make an examination of the ear-drums. Often the only symptom present may be the diarrhea, which persists until the drum has been opened and free drainage allowed. There may be little or no temperature, but it is more apt to be present in cases of malnutrition. Perhaps the most frequent complication is bronchopneumonia. As in the ear conditions, it may be a primary or secondary condition, and in cases weakened from the long strain of an attack of diarrhea, it is frequently the cause of the fatal outcome. Nephritis of the degenerative types is often found in the severe forms of both the infectious and non-infectious diarrheas. The urine may contain uric acid, albumin, blood, and casts. Purpura is more often seen in the membranous type, after the case has progressed to extreme emaciation, and may usually be considered a sign of a fatal termination of the disease.

Prognosis.—In any case of diarrhea in infants or young children, the outcome is nearly always an uncertainty. It is usually, however, in the very young, and the children previously weakened by an hereditary or congenital affection, or an acquired malnutrition that the greater number of deaths occur. If the cases receive proper care during the time of an attack, prompt medical assistance, and have sufficient resistance to withstand the disease one may say that the outcome will be favorable. Since improved prophylaxis has been obtained in many cities, and the proper care of infants and children is better understood, the death rate as shown by the newer reports has been considerably lessened.

Treatment.—In caring for the individual child, particular attention should be paid, especially during the summer months, to the details of bathing, and as little clothing as possible should be placed on the baby, often nothing but the diaper. He should be kept in the fresh air, precaution being taken to avoid draughts and sudden extremes of temperature. Most important among the preventive measures is the attention to the composition of the food. Above all, the sugar should be reduced to a minimum, and sweetened water must not be allowed. A wise plan is to reduce the total strength or amount of food during the hot spells of weather.

At the onset of diarrhea, there are three cardinal indications; first, stop food; second, give a dose of castor oil; and third, supply plenty of water. A bottle of barley water sweetened with saccharin (one grain to the quart) may be given every three or four hours, according to the age of the child. Water may be given at very frequent intervals during the day in order to supply the fluid drained from the system by the disease. If the child is too feeble to drink it may be given fluid through a medicine dropper. After twenty-four hours or at the most forty-eight hours of this starvation diet, food may be given in suitable amount. Experiments have shown that a food containing only protein fulfills the purpose, and next to this come the starches. This combination may be fairly accurately obtained by the use of skimmed milk. After removing four or five ounces from the top of a quart bottle of milk, without adding sugar, the milk should be modified in suitable proportions, and brought to a boil. As the patient improves, gruel diluents may be used, then the fat may be gradually raised, but on no account should sugars be added until the stools assume a good color and consistency. After this time, lactose may be added.

In many instances, the condition is too extreme for this modification in diet alone to be effective, and it is necessary to use what is known as Eiweiss or protein milk (Finkelstein). A simple and effective method of preparation is as follows: 1. Bring one quart of sweet whole milk to the boiling-point; raw milk is not used as the curd is much tougher; (2) cool to 100° F.; (3) add one tablespoonful essence of pepsin and allow to curdle; (4) pour off the whey and suspend the thick part, or curds, in a muslin bag for two hours; (5) stand the bag containing the curds in eight ounces of cool boiled water for one hour; this is very important and is the secret of success of the process; (6) remove the bag from the water, allow as much water to drip as will and place the curds in a sieve; (7) add one pint of fat-free buttermilk to the curds in the sieve, and stir. It will be found that the curds will pass through in two or three minutes, so the process must be repeated two or three times; turn the bag inside out and put it again in the eight ounces of water, in order to obtain all the curd; (9) pour in the sieve the eight ounces of water which was used to soak the curds; (10) add enough water so that the whole measures a quart; (11) add the proper percentage of maltose-dextrin and put on ice. This food is ideal for the reduction of fermentation in the intestine and hence the diarrhea, which is almost invariably due to the sugars.

As soon as the evacuations are pasty (usually in four or five days), starch and maltose may be added, as the caloric value of the food is low and must be raised as soon as possible. Bottle feedings of skimmed milk may be gradually substituted for the above. Buttermilk may be used alone instead of the above, in some cases. In children over a year old, whole milk may usually be given after the starvation period, either diluted partially or not as indicated.

*Medical Treatment.*—Repeated doses of castor oil or calomel are always indicated when the temperature persists, care being taken at the same time to exclude other foci of infection. Intestinal astringents are rarely useful, except in the later stages of a secondary infection. Even here, their value is doubtful. They are usually given in the form of enemas. Tannic acid or the tannate, and silver nitrate are used in one or two per cent. strength.

Daily colonic flushings are of value only when the temperature persists or for the purpose of dislodging any food masses.

*Symptomatic Treatment.*—For the fever, hydrotherapeutic measures are the only ones to be considered. Hot mustard baths or tepid spongings are of value. An ice cap to the head and colonic flushings usually bring desired results. When the diarrhea is so severe that a stool is passed every few minutes and the infant is in imminent danger of death through

rapid loss of fluid, opium is indicated, and is best given in the form of paregoric, in doses proportionate to the age of the child (♏ i.–ii. under three months; ♏ iij.–vi. from three to six months; ♏ vij. from six to eighteen months), never repeated in less than two hours. These infants will often respond in an astonishing manner to a subcutaneous injection of a thirty per cent. dextrose solution in saline; as much as five ounces may be injected at one time, and if necessary repeated every three or four hours. In conjunction with this treatment, $\frac{1}{1000}$ grain doses of atropine sulphate may be given hypodermically. This not only aids in the absorption of the dextrose-saline solution, but is one of the strongest respiratory stimulants we have. Meteorism usually responds to colonic flushings or the insertion of a rectal tube; the application of stupes is rarely necessary. Sudden collapse can be controlled by a hypodermoclysis of dextrose solution and a large dose of atropine.

Change of climate is always indicated in these cases, as soon as convalescence begins, and will almost invariably shorten the period of recovery.

Prophylaxis.—All over the United States, there has lately been an awakening as to the proper care and training of children. At last, we are beginning to realize that the future of the race depends on the intelligent physical, mental, and moral upbringing of the babies of to-day.

A national Babies' Welfare Association has been formed, with branches in nearly every large city, while many cities have corresponding associations of their own. Municipal governments, through their Boards of Health, are likewise conserving the infant life. Through these different sources, cities have been divided into districts, and each district is supplied with physicians and nurses, who give instruction to mothers and free care to babies during the trying summer heat. A wide-open campaign is now in progress to arouse the pride and interest of mothers, by baby contests, when the baby or babies who fulfill the required physical points are awarded some small prize. Through the eternal vigilance of the Board of Health and the hospitals and different welfare associations, the mortality rate in New York City has been reduced in the past ten years from 15,526 deaths from all causes to 9,868; and from 4,090 deaths due to diarrheal diseases, to 2,218. Besides the education of mothers and prophylactic care of the babies, the question of pure milk has been and is receiving constant attention. Private interests first established milk stations, where as pure milk as could be obtained was either sold for a small amount or in many cases given to mothers for their children.

Later in New York, this enterprise was assumed by the Babies' Welfare Association and the Board of Health, and milk stations are now in operation where not only good milk, but milk modified to the needs of the child may be obtained by the less fortunate part of the population. With the States furnishing inspectors to investigate the cows on the farm, clean transportation of the milk in iced cans and bottles, and better hygienic surroundings for the baby of the poor by means of vacations during the hot season to country surroundings, infantile diarrhea may yet become one of the unknown diseases.

Chronic Diarrhea.—Chronic diarrhea in infants and young children will be divided into four classes, the first three being designated according to the pathological changes found in the intestine—

1. Simple Catarrhal Ileocolitis: (*a*) without ulceration; (*b*) with ulceration.
2. Chronic Intestinal Indigestion.
3. Ulceration of the Intestine: (*a*) in syphilis, (*b*) in tuberculosis.
4. Eliminative Diarrhea.

*Simple catarrhal ileocolitis* is found most frequently following an acute attack of enterocolitis. The acute attack may merge into the chronic. The acute diarrhea cases occur most frequently in the hot summer months, consequently these chronic cases are encountered in the autumn or early winter. General debility, unhygienic surroundings, previous attacks—even though slight—of acute diarrhea, predispose to this affection. In some cases of very young infants, improper feeding may lead to a chronic ileocolitis. This is true even of the breast-fed infant, when the breast milk contains the various constituents in incorrect proportion for that individual baby.

The mild cases are far more common in infants and show a chronic catarrhal inflammation; the more severe types show, in addition, an ulceration of the follicular variety. In the form with ulceration the diarrhea depends upon the accompanying catarrhal inflammation, as the ulcers themselves may not cause thin stools.

The symptoms are often not alarming and the mother may delay seeking medical advice until the condition has become well advanced. There is a moderate diarrhea. The stools are most offensive, three to six movements a day, of thinner consistency than normal, the color varying from light gray to brown. The amount of wasting usually varies directly with the daily number of stools—the greater the frequency, the more rapid the emaciation. But even with a moderate number of stools there is a steady loss in weight and strength. The temperature is not elevated—on the contrary, it is often found subnormal.

The general condition is poor. The face is pinched, and tongue and skin dry. A moderate degree of anemia is present. These children are irritable, nervous, and sleep very poorly.

Abdominal examination reveals nothing abnormal, unless there is excessive flatulence, when there may be slight abdominal distention. The prognosis in these cases depends, of course, upon the severity of the lesions and whether ulcers are present or not. As this often cannot be determined by the symptoms alone, a careful history of the severity of the previous acute attacks may be of great aid. The prognosis is exceedingly doubtful if the condition has lasted over months, if the child shows extreme emaciation, if there is edema present, or if there are petechiæ over the surface of the abdomen or lower extremities.

The treatment consists in careful regulation of the diet, in treating the general condition, with local treatment and drugs as possible aids. Fats and starches are usually at fault, so one must rely upon albumin, meat broths, skimmed milk, milks with an excess of protein as the Eiweiss of Finkelstein, or the lactic-acid milks. After the stools are normal, one may gradually increase the fat content of the milk. The malted foods form a valuable addition to the diet after the diarrhea has ceased, and, being easily absorbed, aid in more rapidly increasing the weight If these increase the number of stools, their use should be discontinued.

These children are often greatly helped by a change of air. In any case, one should keep the child as much as possible in the open air and sunshine, and the skin should be kept active by a warm tub bath (98°) daily, followed by a cold splash to the chest. Massage of the extremities with olive oil or cocoa butter is often of value. Little reliance can be placed upon drugs, except as they improve the general condition, such as the iron preparations in the cases with anemia. Rectal irrigations of warm salt solution, used occasionally, are of some use, but routine irrigations are contraindicated. "Diarrhea mixtures," when given over long periods of time, prove valueless. The bismuth preparations may help if given at intervals, but not much dependence can be placed upon them. These cases are apt to have acute exacerbations of diarrhea, which should be treated according to the method outlined for the acute disease.

Prolapsus ani is a frequent complication and often most difficult to treat, owing to the constant slight straining with the frequent stools. Anointing the congested mucous membrane freely with vaseline, and careful manipulation with the child on its face and buttocks elevated over a pillow, will reduce the prolapse. Strapping the buttocks together with a strip of adhesive plaster (two and one-half to three inches wide), in the center of which a hole has been cut, is often most useful in overcoming the tendency. It may be necessary to keep a small rubber tube in the rectum, held in place by small strips of adhesive plaster brought high up in front and back. Stools should always be passed with the child in a recumbent posture.

Chronic *intestinal indigestion* presents a different picture. It is found in older children, usually from two to five years of age. The disease comes on slowly, only rarely preceded by any intestinal upset. The causation is not definitely known but it is supposed to be the early feeding of improper food or a long-continued diet containing an excess of an element which the child cannot digest. Rachitis is sometimes regarded as a predisposing factor.

There is very little anatomical change in the intestine, the indigestion being a manifestation of a functional disorder only. After the disease has persisted some months, there undoubtedly develops a catarrhal inflammation manifested by an excess of mucus in the stools and a marked dilatation of the colon. The stools vary in consistency from a semisolid to a thin frothy mass, in which particles of undigested matter can be easily seen, accompanied often by long strings of mucus. The amount of fecal matter passed is very large in proportion to the amount of food taken. The odor is most offensive. The stools are usually light gray or pale brown and vary in frequency from three to six a day. The urine contains an unusually large amount of indican but is otherwise normal. These children present a characteristic appearance; they are undersized, quite thin, with a large abdomen protruding especially over the transverse colon, and very tympanitic. The mental development is not retarded. They are weak, resist active exercise, and sweat easily upon the slightest exertion. The circulation is poor. The disposition changes and they become nervous and irritable. The appetite may be ravenous or capricious.

Recovery, even in the most favorable case, is slow and covers many months. These children should be guarded against infections of any nature, as their natural resistance is lowered, and they succumb easily.

Regulation of the diet plays a most important part in the treatment. With a diet rich in starches, the stools become more frequent, larger in quantity, and extremely frothy and foul smelling. Consequently the diet must exclude the starchy foods and foods which would be apt to ferment, and consist chiefly of rare scraped beef, beef juice, the various meat broths, eggs, and a certain amount of fruit juices. Milk should be withheld for some days and then given skimmed or as whey. Buttermilk, lactic-acid milk, and kumyss are most useful if well borne. Occasionally these children will tolerate olive oil, one teaspoonful given between feedings two or three times a day. Dextromaltose may be used in the various milk dilutions, or the malt foods may be given, if they do not increase the number of stools. Water should be given freely. When the first starch foods, as barley jelly or rice, are tried, it is well to give some form of diastase. After some time stale dried bread may be given.

In starting the treatment of these cases, it is well to empty the intestine with a dose of calomel or castor oil. This may be of benefit repeated at intervals of several weeks. While determining or "trying out" a diet, it is well to keep the child quietly in bed for a few days. Fresh air and sunshine are important factors in the treatment. Moderate exercise, limited by the signs of fatigue, systematic breathing exercises taken in the open air, as well as those calculated to strengthen the muscles of the abdominal wall, massage of all the muscles, followed by active and passive motions, do much good. Warm baths, followed by the cold splash and a brisk rubbing, are also of service. The use of a flannel binder over the abdomen, applied with the child in the recumbent posture, is to be recommended. Anemia is practically always present and it is wise to give the various iron tonics at intervals. Rectal irrigation with two quarts of warm salt solution, or the passage of the rectal tube, is of benefit if used occasionally. The amount of mucus passed has been known to have been materially increased by the too constant use of rectal irrigations.

*Syphilitic ulceration* is extremely rare in infants and young children and requires mention only. There have been reported cases with a chronic diarrhea lasting for months, which clear up quickly under anti-syphilitic treatment.

*Tuberculous ulceration* of the intestine is seen in children, usually over three years of age. It is practically always associated with tuberculosis elsewhere, but for a long time the only symptoms may be a chronic diarrhea alternating with periods of constipation.

The ulcers are small, irregular, frequently involving Peyer's patches, and may become so large as to encircle the intestine. There may be present, also, a plastic peritonitis. In the later stages free fluid may be present in the peritoneal cavity and the lymph nodes may be quite large and easily palpable, when the diagnosis becomes clear. Early cases are distinguished at times with great difficulty from the chronic intestinal indigestion cases. In tuberculosis, the abdomen becomes gradually generally distended, with slight general or deep tenderness. Loss of strength precedes loss in weight and may be out of all proportion to the other symptoms. It is rare not to find slight elevations of temperature, if the temperature is carefully taken and recorded three times a day. Signs of tuberculosis elsewhere, especially in the lungs, should be most carefully looked for, and the stools examined for the presence of tubercle bacilli. Traces of blood in the stools or a true hemorrhage point to tuberculosis. In cases of doubt, palpation of the abdomen under an anesthetic may give valuable information, disclosing enlarged mesenteric glands or masses of thickened omentum, which would establish the diagnosis at once.

The treatment in a case of tuberculous ulceration should never be directed to the intestinal symptoms alone, as the general treatment is far more important.

The diarrhea often subsides upon rest in bed and a carefully selected diet, comprising only most easily digested articles of food. Rectal irrigation is not used in this condition.

*Eliminative diarrheas* are those which are due (1) to the action of some toxin or irritant, or (2) to nature's effort to rid the body of an excess of fluid. In these cases no treatment is indicated for this condition other than that indicated by the primary disease, unless the loss of fluid is too great. In this case the frequency should be checked by small doses of some form of opium.

E. L. JEFFERIS.

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**Diastases,** or amylases, are enzymes widely distributed throughout nature which are capable of hydrolyzing starch to maltose or dextrose with dextrins as intermediate products. See also *Enzymes.*

F. P. U.

**Diastasum, Diastase.** U.S.P.—An unorganized ferment, or enzyme, occurring in plants, especially in seeds during germination, and possessing the function of converting their starch into sugar (maltose and dextrose). The U.S.P. requires that it be obtained from an infusion of malt and should be capable of converting 50 times its own weight of starch into sugar. The diastase of barley and its relatives is best known. It is the agent which converts the starch into sugar in the manufacture of malt. It is not present, or at least not in appreciable quantity, until germination occurs, when it is developed from some other body present. Its amount increases up to a certain stage of germination, when it begins to decrease. When at its height, about one-fifth of one per cent. of the original weight of the seeds can be extracted as commercial diastase. Like other enzymes, it does not combine with the substance upon which it acts, and is not itself consumed in the process, except by the application of undue heat (above 125° F.), and is still present in the malt. The several forms of extract of malt upon the market, either so called or sold under fanciful copyrighted names, contain various amounts of it.

Pure diastase, like pure pepsin, is unknown, but the substance known to us under this name is a white, or at most pale yellowish, odorless and tasteless powder, soluble in water and weak alcohol, but precipitated by strong alcohol. Albuminous matter and sugar are its common impurities. The readiness with which it digests starch under artificial conditions suggests its ability to do so in the stomach during the early stages of digestion, before it is destroyed by the free acidity of the gastric juice, and experiment has demonstrated that such is the case. Diastase is readily subject to standardization, but all the processes are tedious and rather complicated. They depend upon the power of a standard diastase solution to digest a certain amount of starch within a specified time, under fixed and carefully regulated conditions. It is to be remembered that their only value for determining the relative activities of different samples of diastase lies in the rigid uniformity of the conditions of trial. No statement that a certain diastase or diastasic substance converts a certain amount of starch, as contrasted with some other, is of the slightest value, except upon this condition. The dose is gr. ij. to x. (0.12–0.6) and it must be taken with the meal, preferably during the latter part, or just at its close, when the hydrochloric acid, having entered into combination with the proteins, cannot inhibit its action.

Taka diastase is diastase found "crystallized" upon the roots of certain species of *Aspergillus* and removed in water. The removal of diastase from various species of fungi for use in the production of fermented liquors has long been in vogue in Japan. Some years ago Dr. Jokichi Takamine studied the effects of these substances and selected that derived from the above species for medicinal use. He named it as above because "taka" means *high* in Japanese, and forms the first part of the name of the investigator. The method of production is thoroughly to sterilize wheat bran, and to sow it with a pure culture of the spores of the *Aspergillus.* After about fifty hours' exposure to a warm and moist atmosphere, there is an abundant crop of the fungus, which then bears its highest percentage of diastase. If left longer, the diastase would be consumed. The mass is now quickly cooled, broken up and percolated with cold water. The percolate is evaporated in a vacuum pan to a syrupy consistence, this liquid being ten times as strong as ordinary malt. From it the diastase is precipitated by strong alcohol, removed, and dried in the form of a yellowish-white, odorless powder of pleasant taste. Under the most favorable conditions, it digests three hundred times its own weight of dry starch, or ten times as much cooked bread or other similar starchy food. Under ordinary conditions it digests from one hundred to one hundred and fifty times its weight of dry starch. Experiment has fully demonstrated that a similar result takes place in the stomach during the first hour or two of digestion. It is even believed by some that it can pass through the stomach and continue its work in the duodenum, but undoubtedly its principal work is performed in the stomach, as stated. By encasing it in keratin capsules or pills, it can be made to pass through the stomach and be freed for work in the duodenum. The ordinary dose is gr. iiss. It should be taken immediately with the meal.

Henry H. Rusby.

**Diathermy.**—(See also *Electrocoagulation.*) In 1896 d'Arsonval recognized the fact that if currents of high frequency be passed through the body there follows a decided rise of temperature in the tissues traversed by the current. This thermopenetrative property has been studied by Nagelschmidt, Doyen, and others, and various names have been given by them to the methods of utilizing this property as, *Diathermy* and *Transthermy* by Nagelschmidt, *Thermopenetration* by d'Arsonval, and *Electrocoagulation* by Doyen.

The apparatus used by Doyen, and the similar one used by Bainbridge at the New York Skin and Cancer Hospital, consists of a portable stand which contains rheostats, ammeter, fuses, switches, etc., from which lead the wires—one pair to a small motor and the other pair, which conducts an alternating current, to a transformer. A rolling table supports a Ferrié sparking device, composed of a large-toothed wheel made to revolve very rapidly between two fixed copper plates connected to the source of high-frequency and to a d'Arsonval condenser.

The sparks pass between the copper plates and the revolving teeth of the wheel. The number of revolutions of the wheel can be regulated from the switchboard, thus increasing or diminishing the number of sparks at will. A solenoid is placed in the circuit, and this, with a milliampere meter to indicate the amount of current passing through the patient, completes the outfit. Two wires pass from the solenoid to the two electrodes placed upon the skin of the patient.

The electrodes should be made of thin sheets of metal—lead, tin, or aluminum—with the edges covered by strips of adhesive plaster to prevent sparking and the consequent burning of the skin. In simple diathermy, in which the sole object is the heating of the tissue without destruction, the electrodes must be of large size, from 200 to 500 square centimeters, and must be maintained in firm contact with the skin by means of bandages. It is not necessary to have the electrodes wet but if the skin is quite dry it is desirable to moisten it with a few drops of water before binding on the electrodes.

It must be borne in mind that as high-frequency currents pass in a straight line from electrode to electrode, the metal sheets must be so applied that the part under treatment lies directly in the path of the current. The current produced by the various apparatus in use has a voltage of from 1,500 to 10,000, with approximately 1,000,000 to 3,000,000 oscillations per second, and a very high amperage. It is possible to pass as much as two to three amperes through the body without danger to the individual and Bergoiné has reported one instance in which he was able, experimentally, to pass seven amperes through a patient.

The sensation of the patient is the best guide for determining the amount of current to use in a given case; as soon as he complains of the heat becoming uncomfortable the strength of the current should be reduced. Great care must be exercised in the use of diathermy over scar tissue, or in other situations in which there is scanty blood supply, as it is very easy to produce a severe burn without the patient being aware of the condition because of the few nerves present and because the poor blood-supply prevents the cooling of the tissue.

The purpose of diathermy is to produce a localized heat in the deep tissue. For this purpose it acts better than any other known agent. Other forms of heat, as hot water, hot air, etc., act energetically upon the surface, but they have no penetrative qualities because of the feeble heat-conducting property of tissue. On the other hand, high-frequency currents heat to any depth and to any degree, as heat is produced along the entire path of the current. Furthermore, it can be applied directly to the part requiring it.

When the frequency of an alternating current exceeds 10,000 per second certain phenomena are observed which differ very materially from those observed when other forms of electricity are used. The application of a current the alternations of which are less than 10,000 per second is attended by considerable pain and contraction of the muscles, but as the alternations are increased pain and contraction cease and there is no sensation except a very agreeable one of gentle heat. There is a rise of the general temperature as well as a local increase, of from 1° to 4° F. accompanied by frequency of the pulse, a dilatation of the peripheral vessels, with profuse perspiration, and a lowering of the blood pressure. The vessels of the kidney are likewise dilated, causing thereby an increase in the amount of the urine excreted.

Durig and Grau have made a careful study of the effects of high-frequency currents upon the functions of the body and have recently published their conclusions. These observers show that the effects can be attributed solely to the heat produced by the current in the tissue, and not to any specific action of the electricity.

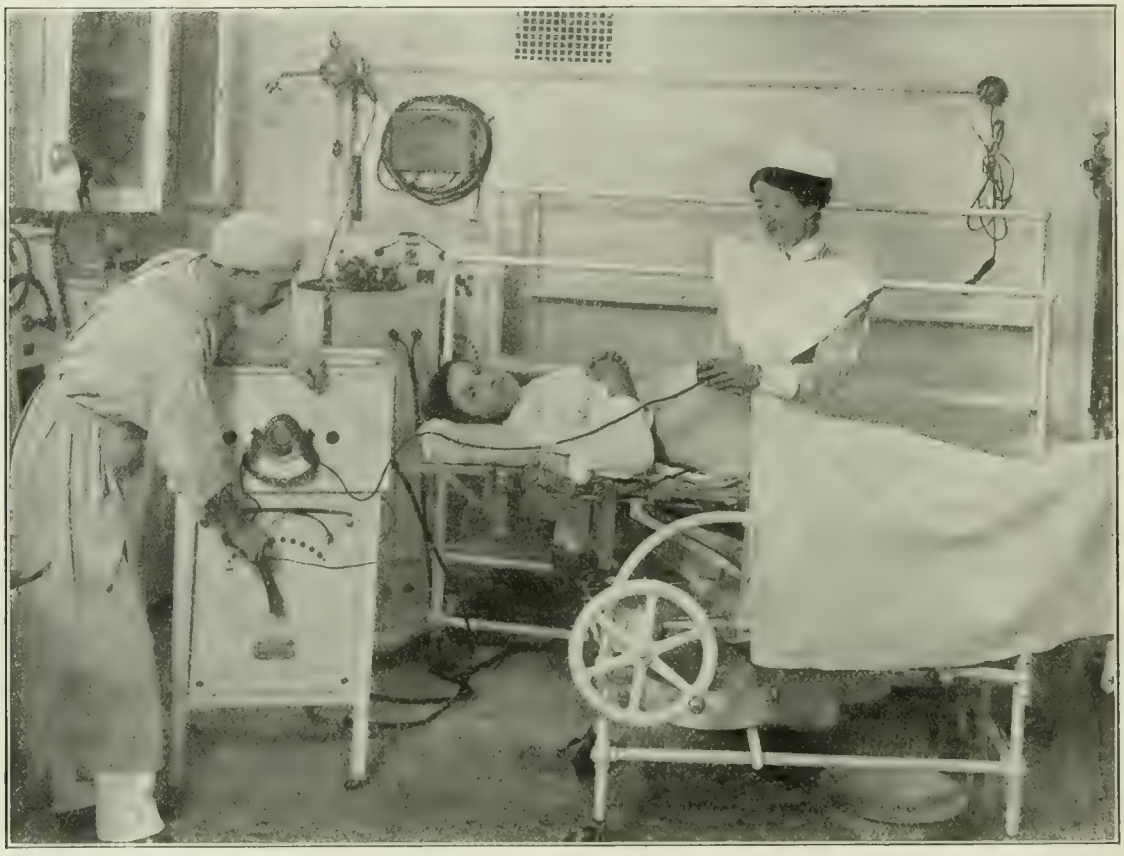

Fig. 1669.—Diathermy Preliminary to Application of the X-ray in the Treatment of an Inoperable Carcinoma of the Uterus. One electrode is applied over the lumbar region and the other, kept in firm contact with the skin by the nurse, is placed directly over the growth.

The high-frequency current has no electrolytic action, as can be easily proved by placing the electrodes in water. If the direct current is used bubbles of gas are seen to be given off from the electrodes, but this does not occur when the high-frequency current is used; there is no action except a heating of the water.

When electrodes of equal size are placed on opposite sides of the body the maximum degree of heat will be found very nearly equidistant between the two, but if one electrode is smaller than the other the greatest heat will be found nearer the small electrode. This fact can be made use of in treating deep organs, as the heart, that are nearer one surface than the other.

The current may be used in sufficient strength to cause coagulation of the tissue and is employed in the destruction of neoplasms, removal of adenoids, etc. This will be more fully covered in the article on *Electrocoagulation.*

Uses.—Nagelschmidt reports a number of cases of nephritis treated by diathermy. He uses large electrodes, pressed as near to the kidney as possible, and passes a current of 1,500 to 2,000 milliamperes for from five to sixty minutes daily for about six weeks. After the treatment has been discontinued, he notes a disappearance of the edema and a diminution in the amount of albumin.

Diathermy is used for heating cancerous tissue in inoperable cases, in order to render the tissues more sensitive to the action of the *x*-ray. This claim has been made by de Keating-Hart and other observers and the method is called thermoradiotherapy (*q.v.*).

Diathermy has a special field of usefulness, according to Nagelschmidt, in the treatment of angina pectoris and other diseases of the heart. If the heart muscle is to be heated a large indifferent electrode is placed over the back and a smaller movable electrode anteriorly over the base of the heart. The small electrode should be of such a size that 1,000 to 1,200 milliamperes can be passed for five minutes without discomfort to the patient. If the heat is complained of a larger electrode should be substituted. The pulse usually is increased from twenty to thirty beats. This is excessive in feeble patients or when the blood pressure is low. Nagelschmidt uses the method in commencing arteriosclerosis and reports cases in which, after nine treatments, the blood pressure was lowered eighty millimeters.

Bergonié employs diathermy in cases of hypothermia occurring after anesthesia, in severe hemorrhage, after extensive traumatism, severe burns, and other conditions in which there is a period of algidity. This observer uses one and one-half amperes for about forty minutes.

Benefit follows the use of the method in the treatment of bronchitis, bronchopneumonia, sciatica, lumbago, and joint affections, as in acute gout, rheumatism, and gonorrheal rheumatism.

Worthington Seaton Russell.

**Diathesis.**—Stedman's Medical Dictionary defines this term as "a constitutional state predisposing to any disease or group of diseases" and this undoubtedly is the common meaning of this useful concept. The province of modern science is not only to learn, to store, and to promulgate absolutely known and wholly definite facts, for science should suggest (on the basis of its normal imagination) general ideas, principles, relationships to be filled out and made explicit by the researchers and thinkers who are to come. Such a term is diathesis and its explicity is not so far away either from the present day, for the new doctrine of the internal secretions (why not term it hormonology?) affords a new lead, it may be, straight into its still more or less uncertain significance. Psychophysiology has an homologous term, temperament, which no competent person has striven to abandon as superfluous or confusing. Indeed, diathesis, although in fact a relic, as temperament is, of an earlier and less minutely descriptive scientific age, means more and more as a pressing topic of research; as a reminder of the total unification of living structure and process; as a convenience of much practical utility in practical medicine. When some analytic mind begins simply enough, that is with elements simple enough and with methods of corresponding definiteness and simplicity, both temperament and diathesis, or morbid temperament, will be seen to be explicit concepts and important in the science of animals and plants. The great Claude Bernard teaches us wisdom thus: "La médecine n'est point la médecine des êtres vivants en général, pas même la médecine du genre humain, mais bien la médecine de *l'individu* humain, et de plus la médecine d'un individu dans certaines conditions morbides qui lui sont spéciales:" "Medicine is not the medicine of living beings in general, not even the medicine of the human race, but rather the medicine of the human *individual* and above all the medicine of an individual in certain diseased conditions which are peculiar to him." How often have commencement orators striven to impress upon the already oversclerosed cortical neurones of the *cands. med.* the necessity of treating the patient rather than his disease; the whole "case" and not the supposed contents of the case appearing to a cursory view! The specialist has much that is well worth while yet to learn, but no one thing more essential than the total and eternal unification of all that concerns the individual *life*. The idea diathesis is important as a reminder to the overspecialist that there are still things to be learned, "for life is greater than we think who fret along its shallow bars."

Bailhache in his doctorate thesis (Paris, 1897) on the diatheses suggests their characteristics, and defines the condition in general as a constitutional mode of special nutrition, definite, permanent, and vicious; *a morbid temperament*. He inclines to think of the diatheses as neuroses, neuroses produced by the actions of certain organic poisons—a shrewd opinion for seventeen years ago, when the hormones and kolyones and their intimate relationship to the nervous system (*e.g.* adrenalin acts only on smooth muscle containing sympathetic neurones) were still unguessed or at least unknown. So much indeed, has been of late uncovered concerning the all-pervasive influence of the autonomic system (especially its larger portion, "the sympathetic") that any year now might see adequate exposition of the psychophysiology of the temperaments in terms more or less of chemistry, neurology, and protoplasmic behavior. And when this is set before us we probably shall be able to discern just behind it the theory of the diatheses, for diathesis may be considered, in a sense, a half-way state between physiologic normality and actual disease, especially such as is basally metabolic in its nature.

Lyman tends to try to lay an anatomical basis for diathesis when he speaks of it as a "rearrangement of structural units predisposing to disease."

H. E. Hering of Prague, in a recent article (*Münch. med. Woch.*, 1911, S. 721), emphasizes the two aspects of diathesis—dyscrasia and disposition. Dyscrasia is a general morbid state of the blood due to the presence of toxins of some sort or other, while disposition refers more naturally perhaps to the constitution of the protoplasm or tissues proper; it is the peculiar and timely thesis of Hering that these, being inseparable in fact, should be considered so in doctrine. Thus for Hering a diathesis is a "cellular-humoral correlation."

Into the history of the diathetic notion in medicine we need not go, so involved is it with numerous traditional errors of fact now outgrown.

Its general nature, on the other hand, is our proper study. Nowhere can be found more careful analysis of the meaning of diathesis than in the writings of the French physicians, and of these Julien Bailhache, already mentioned, has perhaps the most scientific of the discussions since Bouchard's classic *Traité de Pathologie générale*, and one of the most recent to be found. Bailhache points out that despite the disagreement certain in doctrinal matters between his "school" (that of l'École de Paris) and the system of l'École de Montpellier, in at least seven important respects they are in accord respecting diathesis. These points, which excellently explain the nature of our topic, are in his own words translated as follows:

1. A first point on which there is complete agreement is that the diatheses are essentially *chronic and permanent*. Bouchard (de l'École de Paris) defines diathesis as "a permanent disturbance of the nutritional process" (des mutations nutritives). Grasset (de l'École de Montpellier) on his side declares that "diathesis is always a chronic affection." Lancereaux

considered herpetism (the gouty or arthritic diathesis) a permanent affair beginning and ending with life. It is then needless to insist on this.

2. In like manner it is admitted at Paris as at Montpellier that diathesis can remain *in a latent condition* for many years. Grasset writes thus: "The diatheses can exist during a period sometimes very long without manifesting themselves by a single symptom. Diathesis by its nature can remain latent. It remains thus latent in an individual during all the intervals separating the appearances of the manifestations. It can even remain latent during the whole life of an individual." On his side Hallopeau, who, following Bouchard, considers diathesis a simple predisposition, writes in his *Traité de Pathologie générale:* "The abnormal states termed diatheses differ essentially from chronic maladies. They can practically remain latent for many years and even during the greater part of life, and reveal themselves only accidentally through the qualities of a passing affection."

3. In the third place, everyone recognizes that the diatheses concern the entire organism, that they are *constitutional.* Lancereaux defines herpetism as "a disease essentially constitutional and hereditary." Grasset affirms that "diathesis is always a general malady," and adds "this proposition can be demonstrated (?) simply, I believe, by the unanimous agreement of medical men. Either one does not admit diathesis at all or, if he admits it, one recognizes it as a constitutional disease, totius substantiæ." "Le Dictionnaire des Sciences Médicales," published by Dechambre, Mathias Duval, and Lerboullet, expresses itself thus: "Diathesis is a morbid general disposition of the economy." I shall content myself with these quotations and pass to another characteristic which is less generally admitted.

4. The manifestations of diathesis are *many* and *various.* The whole work of Bouchard on the *Maladies par ralentissement* (depression) *de la nutrition* has properly no purpose other than to establish the close relationship that exists between a multitude of affections heretofore considered independent. Bouchard has shown that a common bond unites these conditions and this bond is the bradytrophic diathesis, arthritism ("suboxidation.") Similarly, Lancereaux, speaking of herpetism, or more explicitly arthritism, says that this is a disease "characterized by dynamic disorders of the three great nervous functions, of trophic lesions of the skin and mucosæ (teguments), and of the locomotor and hemic systems. Finally, Grasset having formally affirmed that the manifestations of the diatheses are essentially multiple and various, goes on to say "This is to me one of the most essential characteristics, one of the ideas which is most indispensable in the constitution of the diathetic idea. No diathesis is characterized by a unique and special lesion."

5. The diathetic manifestations are not *critical* of the diathesis; or if one prefers it so, they do not exhaust or overcome the deep cause which occasions them. The truth of this proposition is easily demonstrated. Is an arthritic cured of his diathesis by an attack of neurasthenia? On the contrary, he is worse off than before the attack. It is the same in the case of the lymphatics. Here is what P. de Gennes says in the "Traité de Médecine" de Brouardel: "Tonsillitis is extremely frequent among the scrofulous (one should read, the lymphatics). It is repeated several times every year, and each time leaves the tonsils a little more enlarged so that in a short time they touch or nearly touch each other; then the respiration becomes difficult and the voice nasal in sound." From this quotation it is apparent that the more a scrofulous (or lymphatic) person has experienced the manifestations of his diathesis the worse state he is in. A final example alone will carry conviction: at the Medical Congress in Bordeaux in 1895 Hanot declared that "according to his observations cirrhosis occurred especially among the arthritic." Thus one may scarcely maintain that an arthritic is less ill when he becomes cirrhotic.

The school of Montpellier also defends this opinion: "Rheumatism or gout," says Grasset, "is not exhausted by arthritic attacks; one can say on the contrary that the longer the diathesis lasts the more is it reinforced."

6. Another characteristic of the diatheses, a leading characteristic, is this: the affections with common causes and the parasitic and microbic affections are influenced and modified by the different diatheses. For example, it is a fact well recognized by all the world that tuberculosis evolves in a special manner in the arthritics. In 1869 Maurice Raynaud announced this fact in his article on Diathesis in the "Dictionnaire" de Jaccoud: "It has been remarked that in the gouty phthisis is ordinarily limited to the apex, that the destruction of the lung proceeds slowly, without reaction and in an almost latent manner, etc." And very recently Sarda and Vires (of Montpellier) published a "memoir intending to show the rarity of pulmonary tuberculosis in the arthritic, the resistance which the arthritic diathesis (by the production of fibrous tissue in one part and by the composition of the humors)—blood and lymph—(in another), furnishes against the attacks of the bacillus and the progress of the lesions; the periods of arrest which it compels; the cures which it makes possible." And, in the work which I have already cited, P. de Gennes, speaking of scrofula (lymphatism) defines it as "a special soil in which grows with the greatest facility the tubercle bacillus as well as other disease germs which produce lesions of a particular sort."

7. Then there is a last characteristic on which there is equal equanimity: diatheses can be *hereditary* or they can be *acquired.*

But here it is important that it should be clearly understood what is meant by this word hereditary, for, as Fournier has said "in medical language the word heredity has a meaning other, more circumscribed, better defined than in common language. . . . . Heredity for medicine is no longer 'all that passes from the ascendants to the descendants' —it is only that which is transmitted *at the time of fertilization.* It is that which is brought to the germ, to the future embryo, in the way of qualities proper to the two generative cells (spermatozoon and ovum) at that moment when from the conjugation of these two elements there results the mysterious process of fecundation." It is certainly in this sense that we must speak of the heredity of the diatheses.

But this heredity is so evident a fact that no one dreams of denying it. On the first page of his "Traité de Herpetisme" Lancereaux says that this disease is "inherently hereditary," and herpetism is a diathesis. In the *Traité de Pathologie générale* of Bouchard, Le Gendre writes: "The heredity of the arthritic diseases proclaimed by Bazin, opposed by Guéneau de Mussy, has been cleared up by the clinical statistics in the lessons of M. Bouchard on the slowing-up of the nutrition." And some pages further on, Le Gendre shows that the heredity of scrofula (lymphatism) is a fact. From the viewpoint of the Montpellier School, here is what Grasset says in his article in the "Dictionnaire" Dechambre, already referred to a number of times: "At the head of the causes of the diathetic disorders one must place heredity, which certain authors have even placed in the definition of diathesis. We have not considered the hereditary characteristic an essential element of the notion of diathesis because a disease seems to us to be able to be diathetic without arising in heredity (syphilis for example) and before being capable of transmitting itself by heredity." I for my part (says Bailhache) do not accept the example that Grasset has selected but it remains none the less

that Grasset admits hereditary diatheses and acquired diatheses. Finally, a last quotation is typical; I borrow it from the treatise of Proust and Mathieu, the "Hygiene du Goutteux" (gouty). "Not every one who wished it could become gouty. Of two individuals placed in exactly the same hygienic circumstances one would take the gout, the other remain immune. In England, the classic land of the gout, there are, say the authors, some families in which the predisposition to this disease is so marked that their members can in no way escape it . . . On the other hand, one sees parvenues become gouty, the issue of families of robust countrymen among whom gout, obesity, diabetes were wholly unknown . . . . . parvenues to gout as they are parvenues to fortune."

In fine, the School of Paris and the School of Montpellier agree on the following seven characteristics for the concept of diathesis: 1, the diatheses are chronic and permanent; 2, they can stay latent for long periods of years; 3, they concern the entire organism or, in other words, are constitutional; 4, their manifestations are numerous and various; 5, and do not cause the destruction of the deep cause which produces them; 6, they impress on the parasitic or microbic or organic affections their own characters; and 7, they may be either hereditary or acquired.

This notion of diathesis as a derangement of general metabolism by the action of agents on the (sympathetic?) neurones the present writer believes to be as scientific as it is prophetic and to offer to competent research a fertile field for more detailed study.

Diathesis should be discriminated from dyscrasia which refers especially to morbid conditions of the circulating fluid. It may not be improper to remind the reader also that cachexia is a term easily confused at first use with diathesis; but the idea in it is not the morbid metabolic condition, but rather the appearance, the facies, the outward manifestations of something wrong within. Four cachexias are especially obvious, the cancerous, the metallic, the malarial, and the asthenic.

The actual diatheses about which it is scientific to speak is a matter in part of the view-point of the speaker. The author from whom chiefly we have quoted, a leading authority on the theory of diathesis seventeen years ago, was inclined to include a syphilitic diathesis in his short list, as already suggested. In Mohr und Stähelin's "Handbuch der Inneren Medizen," 1912, the most recent available discussion of authority perhaps, there are described at more or less length the arthritic diathesis, the exudative, the hemorrhagic, the uric-acid, the neuro-arthritic, the spasmophilic, the asthenic, the ossific, and the fatty diatheses. The *Index Medicus* has a subsection devoted to "Diathetic Diseases, Disorders of Metabolism," with headings for articles on cancer, diabetes, gout, obesity (lipomatous), rheumatic affections, and rickets. In recent numbers of the *Index* articles on acidosis, acetonuria, alcaptonuria, the cyclic vomiting of infants, and ascites are noticeable.

In general it is obvious that the diatheses are real concepts of real use still in medicine, although further knowledge of the internal secretions and of their influences on the vasomotor and sympathetic phases of metabolism is certain greatly to simplify some of them and perhaps to reduce others to the ranks of symptom-complexes of conditions parasitic or infectious rather than primarily metabolic in their etiology. Even so, however, there will still be plenty to be learned about various conditions well termed diatheses in the master marvel, man.

GEORGE V. N. DEARBORN.

**Diazo Reaction.**—Following the discoveries made about 1860 by Griess in regard to the existence of certain colored azo compounds, attempts were made to obtain definite color reactions by using reagents of this group. Weselsky, for example, found that phloroglucin could be identified by its property of combining with nitrodiazobenzene to form a red azo compound. Ehrlich, however, was the first to bring the method into the medical laboratory, and in 1882 he showed that chromogenic substances occurring in the urine could be made to unite with the diazo bodies to form brilliant pigments and recommended the reaction for diagnostic purposes. When carried out under certain conditions the reaction is an indication of pathological protein cleavage, and is never positive in the urine of healthy persons. Various related bodies (such as ortho-, meta-, and para-aminobenzenesulphotoluidine, sulphonaphthylamine, sulphoaminoazobenzene, disulphonic acid, para-nitranalin, dimethylpara-phenylendiamine, para-aminoacetophenone, para-nitrodiazobenzene sulphate, etc.) may be used, and numerous modifications of the test have been recommended by different authors, but Ehrlich found that it was most convenient to employ diazobenzenesulphonic acid and devised a method in which this substance is obtained extemporaneously by the action of nascent nitrous acid on para-aminobenzenesulphonic acid. Two solutions are used, the one containing sodium nitrite, and the other hydrochloric acid and sulphanilic acid. When these are mixed in the proper proportions, the following reactions take place:

1. $NaNO_2 + HCl = NaCl + HNO_2$

2. $C_6H_4\begin{cases}NH_2\\SO_2.OH\end{cases} + HNO_2 = C_6H_4\begin{cases}N=N.OH\\SO_2.OH\end{cases} + 2H_2O$

Para-aminobenzenesulphonic acid. Diazobenzenesulphonic acid.

The latter in the presence of ammonia and certain urinary chromogens produces a brilliant red pigment. The following is the formula for making the stock solutions:

| Solution A. | |
|---|---|
| Sulphanilic acid | 1 |
| Hydrochloric acid, conc | 50 |
| Water | 1,000 |
| **Solution B.** | |
| Sodium nitrite | 1 |
| Water | 200 |

These should be kept in dark bottles.

The reagent is made up by adding 1 c.c. of Solution B to 50 c.c. of Solution A. After mixing, the reagent deteriorates rapidly, especially in warm weather, and though it keeps for one or two days it is best always to prepare it freshly before use.

TECHNIQUE.—Equal volumes of the combined reagent and of the urine are mixed in a test-tube and rendered alkaline by adding several cubic centimeters of ammonia all at once, not drop by drop, and shaking the mixture thoroughly. If the reaction is positive, the fluid becomes deep yellowish-red in color, and the foam is also red or at least distinctly salmon pink. A brownish, yellowish, or orange coloration of the fluid or the foam is not characteristic and should be disregarded. If the reaction is very pronounced a green sediment forms in the bottom of the tube in the course of twenty-four hours, but this is not necessary for the reaction to be considered positive. The ammonia may be poured down the side of the tube so as to form a red ring at the line of contact of the two fluids, and the mixture then shaken, and the foam inspected. Occasionally the substances causing the reaction are present in such small amounts that the result is doubtful, but by concentrating the urine on a water bath it may be possible to secure a well-marked reaction. Simon recommends pouring the mixture from the test-tube into a porcelain basin containing a large amount of water, when a beautiful

salmon-pink color is obtained, even if only traces of the chromogen are present; and he states that this is never seen when the reaction is negative.

*Sources of Error.*—If the amount of sodium nitrite used is greater than as stated, normal urines may react positively. Sodium nitrite as purchased sometimes contains too little nitrite. When a few grains are dissolved in water the addition of a little nitric acid should cause the evolution of copious nitrous fumes, or a drop of potassium permanganate solution added to the nitrite solution should be promptly decolorized by it.

The reaction is well marked only if the urine is acid, and disappears after it becomes alkaline as the result of fermentation, or if it is treated with oxidizing agents like permanganate. Unfortunately many drugs when given internally either cause a reaction closely resembling the true diazo reaction, or diminish or entirely prevent it. Among these drugs are naphthalene, chrysarobin, opium, heroine, dionine, morphine, and alcohol in large quantities. Patients treated with salvarsan may give a suggestive diazo reaction, and the same is true in regard to atophan. Thymol, which is often used as a preservative for urine, gives a red color but a yellow foam. These pseudoreactions can usually be distinguished by the fact that the foam does not show the characteristic color, that the color of the solution does not fade markedly on the addition of strong mineral acids, and that the green precipitate does not appear. Substances which inhibit or prevent the appearance of the reaction are: gallic or tannic acid, tannigen, tannalbin, phenol or salol, the iodides, creosote, creosotal, and guaiacol. As many of these drugs are likely to be administered in cases of tuberculosis or typhoid fever, knowledge of the patient's medication is of importance in interpreting the result of the test. Bile, urobilin, and hydrochinone may interfere with the reaction, and according to Clemens in such cases it is well to clear the urine first by adding a little subacetate of lead or charcoal, and then filtering. Burghart has pointed out that the large amounts of phenol often present late in phthisis or in typhoid fever may give rise to a strong yellow color which makes it difficult to interpret the reaction. The excess of phenol in such urines can be demonstrated by adding strong nitric acid to the urine and boiling. After the mixture has cooled bromine water is added, and if marked turbidity results an excess of phenol may be assumed.

A variety of the reaction, termed the "egg yellow" reaction, in which the fluid and foam are colored deeply yellow and a yellow sediment forms on standing, is due to the presence of urobilinogen.

Nature of the Reaction.—Various urinary constituents are known to give a diazo reaction, though not usually in the characteristic form seen in the urine in typhoid fever, chief among them being antoxyproteic acid and bodies containing the imidazol nucleus (aminoimidazol propionic acid, histidin). Tyrosin gives it, as well as its oxidation products, para-oxyphenylpropionic acid and paraoxyphenylacetic acid. Weisz considers the reaction as due to an undetermined substance allied to proteic acid and closely resembling urochromogen in its properties. Acetone and diacetic acid are also said to give a similar reaction, though in the writer's experience this has never been found to be a source of error.

Clinical Interpretation.—Although various observers, as Penzoldt, Petri, Karthin, and others, have found the reaction positive in normal urines, they did not adhere to the Ehrlich method of performing the test; and while the recent work of Bondzynski on antoxyproteic acid makes it possible that there is a gradual gradation between normal and abnormal urines, it is the opinion of most clinicians that when properly performed the reaction is never found in the urine of healthy persons. In general, it may be said that the diazo reaction is rarely positive in afebrile chronic conditions, but that it occurs in a wide variety of febrile disorders. Ehrlich divided the latter into three groups: first, those in which it is nearly always present; second, those in which it is sometimes, but not always, present; third, those in which it is almost never present. In the first group he placed typhoid fever, typhus fever, advanced pulmonary tuberculosis, and measles; in the second, pneumonia, scarlatina, diphtheria, and erysipelas; and in the third, articular rheumatism, meningitis, roseola, and varicella. Subsequent observations have done little to alter this classification, although newer methods of diagnosis have lessened the clinical importance of the test.

Typhoid Fever.—In typhoid fever the reaction appears in from seventy to eighty per cent. of the cases toward the end of the first week or the beginning of the second, and usually persists for a week or ten days. It is, therefore, most constant during the period before the Widal reaction is strongly marked, and it is also of interest that it usually reappears if a relapse occurs. The intensity of the reaction is generally in harmony with the severity of the infection, whereas the agglutination reaction is often strongest in the lighter cases. Different epidemics of the disease vary, however, in the constancy with which the reaction appears. For example, in the Detmold epidemic of 1904, Levy found that it was present in only one-half of the cases, and Clemens states that in other epidemics it has varied between fifty and ninety per cent. of the cases. Its occurrence in miliary tuberculosis and ulcerative endocarditis also lessens its value in differential diagnosis. The presence of large amounts of phenols, which is common in severe cases of typhoid fever, may obscure the reaction as noted above.

Tuberculosis.—In the rapidly progressive cases of pulmonary tuberculosis with marked destruction of lung tissue, the reaction usually appears early and continues present throughout the course of the disease. In the chronic forms there is more irregularity in its occurrence and it is seldom positive until the lesions are far advanced. During exacerbations it may be present for a time, only to disappear again during an ensuing improvement; but if the patient dies from the progress of the pulmonary lesions and not from some complication, the reaction is usually positive for some time before death occurs. As a rule the reaction is not seen in the light cases, while it is common in those of more severe or advanced type. On the other hand, it is sometimes present in the latter also, so that the mere fact that the diazo reaction is negative does not necessarily mean that the case is a mild one. If the reaction is positive from the outset it indicates that even though the physical signs may not be pronounced the disease will probably run a severe course. The persistent occurrence of the reaction is a sign of grave import and such cases are by many clinicians considered unsuitable for sanatorium treatment. Wood gives the statistics of 230 advanced cases of pulmonary tuberculosis, fifty-two of which ended fatally. Of these, ninety per cent. gave a strong persistent diazo reaction, but, on the other hand, he also found that ten per cent. of the patients giving a strong diazo on the first examination were susceptible of cure by proper treatment. Shortly before death an increase in the amount of phenols excreted may cause apparent disappearance of the reaction, and severe nephritis may inhibit the reaction through retention of the chromogens. The injection of tuberculin frequently causes the reaction to become positive, especially if there is a rise in temperature. While there is no doubt that the reaction is especially frequent in cases in which there is mixed infection with streptococci, it can be produced by the tubercle

bacillus and its products alone, as is shown by the fact that the injection of tuberculin will produce the reaction in the urine of animals. In differentiating between tuberculosis and syphilis of the lung, a positive diazo points to the former, but it is not possible to differentiate tuberculosis from influenza or actinomycosis by this means. Miliary tuberculosis and tuberculous meningitis both give a strong reaction, but in non-tuberculous forms of meningitis it is always negative. Advanced cases of articular tuberculosis may give the reaction and pleuritic exudates when accompanied by the reaction are to be regarded as tuberculous. In afebrile cases of ascites a positive diazo aids in ruling out cirrhosis of the liver, but does not necessarily exclude peritoneal carcinosis or sarcomatosis.

An interesting but as yet unconfirmed observation has been made by J. R. Williams, who found that the diazo reaction rarely occurs in tuberculous negroes, even when the disease is advanced, and concluded that the absence of the reaction in patients of this race has no diagnostic significance.

Other Conditions.—In most acute infections the diazo is present, but it is not common in *pneumonia*. Sometimes, however, the egg-yellow reaction occurs in this disease, especially in the cases in which the skin is icteric. In yellow fever, it seems to be present in about one-third to one-half of the cases. It is sometimes seen in *malaria*, especially in the cachectic cases. Bernstein calls attention to the fact that the reaction is very commonly seen in trichinosis. In measles the reaction is found in about 85 per cent. of the cases, but apparently its intensity has no association with the severity of the infection. Sometimes it does not appear until after defervescence and lasts only a day or two. In *scarlet fever* it occurs less frequently, but is generally seen in the cases with high temperature. In differentiating between rötheln or a drug rash, and scarlet fever or measles, a positive diazo would indicate one of the latter. *Chickenpox* occasionally gives the reaction. The reaction is not present in uncomplicated *diphtheria*, but it is often seen in the septic cases as well as in instances of sepsis of doubtful origin, including ulcerative endocarditis. *Carcinoma* gives the most marked reaction only when the tumor is of good size and is ulcerating, but the urine of patients with diffuse peritoneal carcinosis usually is strongly positive.

The occurrence of the *reaction in animals* has been studied by Huber who found it to be present in dogs somewhat as in human beings. The horse, cow, goat, sheep, and rabbit give a red reaction; pigs and calves a red or yellow. Jansen has found that the ordinary infectious diseases of the domestic animals do not cause the reaction to the extent one would expect from the results in human beings.

*In conclusion* it may be said that the presence of the diazo reaction indicates an intoxication usually as the result of bacterial activity. In a general way it corresponds in intensity with the severity of the infection, but this rule is open to many exceptions through variations in the propensity of the individual to excrete the diazo chromogens. There is also a tendency to the temporary retention of these followed by a period of increased excretion, so that fluctuations in the intensity of the reaction may be caused; and it is not permissible to conclude that the presence of the reaction always indicates a severe infection or that its absence means that the process is a mild one.

Karl M. Vogel.

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**Dibothriocephalidæ.**—A family of tapeworms in which there are two elongated slit-like suckers, the uterus forms a rosette, and the genital pores are ventral. It contains two subfamilies: (1) *Dibothriocephalinæ* with distinct proglottids which drop off in groups. This division contains three genera parasitic in man, *Dibothriocephalus*, *Diplogonoporus*, and *Sparganum*. (2) The subfamily, *Lingulinæ* has only one genus, *Braunia*. See *Cestoda*.

A. S. P.

**Dibothriocephalus.**—A genus of tapeworms, family *Dibothriocephalidæ*, with a more or less elongated unarmed scolex, with flat suckers cutting deeply into it; single genitalia in each proglottid. Three species are found in man: *D. latus*, in man, dogs, and cats, which sometimes contains 4,200 segments and occurs as a pleurocercoid in fish, is common in Europe. *D. cordatus*, usually found in the seal, walrus, and dog in Iceland; *D. parvus*, in Syria. See *Cestoda*.

A. S. P.

**Dibothrium.**—A synonym for the genus *Sparganum*. These worms are long ribbon-like larval tapeworms of the family *Dibothriocephalidæ*. No head or definite structure is visible. See *Cestoda*.

A. S. P.

**Dickinson, William Howship.**—Born at Brighton, England, in 1832. He received his academic education at the University of Cambridge, and entered St. George's Hospital, London, in 1851. The degree of M. D. was conferred upon him in 1862. In May, 1866, he became Assistant Physician to St. George's Hospital; in 1874 he was promoted to the rank of Physician, and in January, 1894, to that of Consulting Physician, in the same hospital. Between the years 1861 and 1885 he held the positions of Assistant Physician, Physician, and Consulting Physician in the Hospital for Sick Children, Great Ormond Street. He delivered the Croonian Lectures in 1876 and the Lumleian in 1888; and in 1891 he was Harveian Orator. One of Dr. Dickinson's colleagues gives the following estimate of the value of his contributions to clinical medicine: "Dr. Dickinson was an all-around physician and wrote on nearly all branches of medicine. His advice was most often sought in consulting practice for diseases of the kidney and of children on account of the book which he published (1875–1885) on renal and urinary affections and because of his long connection with the Hospital for Sick Children; but his contributions to diseases of the nervous, cardiovascular, and digestive systems were numerous and always worthy of attention both for the matter and for the purity of his Addisonian English." He died January 9, 1913.

The following are the titles of some of Dr. Dickinson's more important contributions to medical literature: "The Changes in the Nervous System which follow the Amputation of the Limbs," *Journal of Anatomy and Physiology*, 1868; "On the Visceral Changes in Rickets," and "On Hepatic Cirrhosis in Children"; "On the Morbid Effects of Alcohol as shown in Persons who Trade in Liquor," 1872; "On Dropsy" (Harveian oration), 1891; "On Lardaceous Disease," 1879; and "On the Morbid Anatomy of Diabetes," 1883.

A. H. B.

**Dickson, Samuel Henry.**—Born in Charleston, South Carolina, Sept. 15, 1798. After graduating from Yale College with the class of 1814, he studied medicine first in Charleston and afterward at the University of Pennsylvania. He received the degree of Doctor of Medicine from the latter institution in 1819, and soon afterward began to practise in his native city, Charleston. He was Professor of the Practice of Medicine in the Medical College of South Carolina from 1833 to 1847, and again from 1850 to 1858. From 1847 to 1850 he held the same position in the University of New York. Then, from 1858 until the time of his death, he was Professor of the Practice of Medicine in Jefferson Medical College in Philadelphia. His death occurred in the latter city March 31, 1872.

Dr. Dickson, whose writings were distinguished for the clearness and gracefulness of their style, as well as for the depth and accuracy of the learning displayed, made frequent contributions to both medical and general literature. The following are the titles of some of his published works: "Dengue, its History, Pathology, and Treatment," 1826; "Essays on Pathology and Therapeutics," 1845; and "Studies in Pathology and Therapeutics," 1867.

A. H. B.

**Dicrocœlium.**—A genus of flukes, *Fasciolidæ*, with lance-shaped bodies, and with suckers placed close together. *D. lanceatum* has been found as a human parasite in France, Italy, and Egypt. It occurs in the gall-bladder. See *Trematoda*.

A. S. P.

**Dictophyme.**—A genus of nematode worms. *D. renalis* is found as a parasite in man. See *Nematoda*.

A. S. P.

**Diday, Charles Joseph Paul.**—Born in Bourg, France, in 1812. He studied medicine in Paris, and was made Surgeon-in-Chief of the Antiquaille, a hospital for venereal diseases, in Lyons. By reason of his cleverness and his great industriousness he was able, in course of time, to convert the Antiquaille from a simple hospital into a school for syphilography. He was a prolific writer, and did not confine himself to themes relating only to venereal diseases. He died January 8, 1894. He was one of the best-known and most instructive syphilographers in France during the nineteenth century.

Of his published writings the following deserve to receive special mention: "Traité de la syphilis des nouveau-nés et des enfants à la mamelle," Paris, 1854; "Exposition critique et pratique des nouvelles doctrines sur la syphilis, suivie d'une étude sur de nouveaux moyens préservatifs des maladies vénériennes," Paris, London, and New York, 1858; and "Thérapeutique des maladies vénériennes et des maladies cutanées," Paris, 1876 (in association with A. Doyon).

A. H. B.

**Dieffenbach, Johann Friedrich.**—Born in Königsberg, February 1, 1792. His early studies in theology at Greifswald were interrupted by the war of 1813–14, to which he went as a volunteer, and on returning to civil life he turned his attention to medicine, which he studied at Königsberg during the years 1816–20. In 1822 he accompanied a patient to Paris where he had an opportunity of studying for six months under Dupuytren, Magendie, and others, and also passed a couple of months in the clinics of Delpech and Lallemand at Montpellier. When he returned to Berlin in 1823 to begin the practice of his profession, his attention was turned by Carpue to the Indian method of rhinoplasty, and he followed the subject so assiduously that he became known as the "father of plastic surgery." He wrote many articles on it in the periodicals of the time, and these were collected and published, with additions, in a work entitled "Chirurgische Erfahrungen, besonders über die Wieder herstellung zerstörte Theile des nenschlichen Körpers, nach neuen Methoden," Berlin, 1829–34. His activities were not confined, however, to plastic surgery, as may be seen from the titles of some of his other publications: "The transfusion of blood and the infusion of medicines into the blood-vessels," Berlin, 1828; "A guide for sick-nursing," Berlin, 1832; "Cure of stuttering by a new surgical operation," Berlin, 1841; "Section of tendons and muscles," Berlin, 1841; Squinting and its cure by operation," Berlin, 1842, in which he published a report of 1200 strabismus operations. He lived to see the introduction of surgical anesthesia, and published a pamphlet on his experience with the new procedure, entitled "Der Aether gegen den Schmerz," Berlin, 1847. His work on "Operative Surgery" was published in two volumes (Leipsic, 1845–48), the second volume coming out after his death. He died in harness, the end coming suddenly, while he was operating in his clinic, on November 11, 1847.

T. L. S.

**Dietetics.**—See *Aliment*.

**Diethyl-ketone,** also known as *propione*, or *metacetone*, has the formula $C_2H_5 \diagdown C{=}O \diagup C_2H_5$. It is a thin colorless liquid, obtained from the distillation of sugar with excess of lime. It has an unpleasant taste, smells like acetone, and is sparingly soluble in water, but is freely soluble in alcohol or ether. It is used as a hypnotic and sedative, in doses of ten to thirty minims (0.6–2.0), well diluted.

R. J. E. Scott.

**Dieulafoy, Georges.**—Born in Toulouse, France, in 1840. He received the degree of Doctor of Medicine in Paris in 1869, and almost immediately afterward constructed the apparatus (for the removal of fluid exudations) which bears his name, and about which he has written the following treatises: "De l'aspiration pneumatique sous-cutanée; méthode de diagnostic et de traitement," Paris and London, 1870; "Du diagnostic et du traitement des kystes hydatiques et des abscès du foie par aspiration," Paris, 1872; and "Traité de l'aspiration des liquides morbides," Paris and London, 1873. In addition to the above special treatises he published the following two very popular books: "Manuel de pathologie interne," 11th edition, Paris, 1898; and "Clinique médicale de l'Hôtel-Dieu de Paris," three volumes, Paris, 1896–1899. In 1886 he was appointed *Chef de Service* at the Necker Hospital, and in the same year he was elected Professor of Internal Pathology in the Faculty of Medicine. Ten years later, in 1896, he was called to the Chair of Clinical Medicine at the Hôtel-Dieu, one of the largest hospitals in Paris. (This was the chair that the famous clinical teacher, Trousseau, had occupied twenty years earlier.) In 1910 he was chosen President of the Paris Academy of Medicine. Widal and nine others who to-day occupy high positions in the hospitals of Paris, were at one time or another Dieulafoy's pupils. He died in Paris in 1911.

A. H. B.

**Differentiation.**—(Med. L. *differentiare*, from *differentia*, difference.) Murray defines *differentiation*

as "any change by which like things become unlike, or something homogeneous becomes heterogeneous." In the more special, biological, use of the term it is employed to indicate "the process, or the result of the process, by which in the course of growth or development a part, organ, etc., is modified into a special form, or for a special function; specialization; also the gradual production of differences between the descendants of the same ancestral types." In its biological meaning, then, the term may be applied either (1) to certain phenomena in the development of the individual, or (2) to the origin of species; and in each case it may be used to indicate either (*a*) the process, or (*b*) the result of the process.

Taking these meanings in the reverse order, the result, or state, of differentiation of species (2, *b*) would be exhibited by a comparison of the various organs, tissues, habits, modes of life, and other characters of the numerous species and other groups of both animals and plants. It would involve not only a study of their comparative anatomy, but also of their physiology and ecology as well; and thus would be far beyond the scope of the present article.

For the differentiation of species regarded as a process (2, *a*) the term *organic evolution* is commonly employed, and the subject will be discussed in the present work under that title (see article *Evolution*).

In the individual, as among species, the state of structural differentiation (1, *b*) is inseparably associated with functional differentiation, or division of labor. In order to describe the state of differentiation in any form of animal or plant, it would be necessary to make an extended study of the structure of its various organs and tissues and of the various functions that these parts perform in the economy of the whole. For man the results of such studies are set forth in the books upon descriptive anatomy, histology, and human physiology.

The *process* of differentiation by means of which differences arise in the structure and functions of parts of the organism (1, *a*) may be considered under two headings. First, we have the facts in regard to the processes that have been observed in the study of the development of organisms; and, second, we have the theories that have been advanced to explain these facts.

In no existing form of life is there an entire absence of the state of differentiation in any stage of development of the individual. In the protoplasm of the ameba one may distinguish endosarc and ectosarc, nucleus, and contractile vacuole. The protoplasm of bacteria was supposed for a long time to be homogeneous; but Bütschli has demonstrated that by proper methods of staining two distinct substances may be observed. In the germ cells of all the higher animals and plants it is always possible to distinguish nucleus and cytoplasm. In the ova of many animals the cytoplasm is differentiated into two parts: one which contains nutrient material in the form of yolk granules, and the other which is free from yolk, and in which the process of development begins—not to mention various differentiations in minute structure which cannot be entered into here. The ovum, however, is vastly less differentiated than the adult form, even in the simplest of multicellular organisms.

The process by which the differentiated condition of the adult arises is essentially a cellular phenomenon. In general, development may be divided into three stages: first, cell division; second, growth by the absorption of water and other material; and, third, differentiation. These stages are shown in their simplest forms in the growing ends of the roots or stems of plants. At the tip there is a group of small cells with thin walls and relatively dense protoplasm, in which the nuclei may be seen to be in various stages of cell division. Separated from these by cells in various intermediate stages, there is a zone of cells still having thin walls, but which are much elongated and have numerous large vacuoles in the cytoplasm. In this zone cell division is comparatively rare. It is the zone of growth, and on its proximal side grades off into the next zone, where cell division entirely ceases, the cell walls become thickened, and the cells become differentiated into epithelium, bast, wood fiber, ducts, etc.

In animals the process is not so simple, nor is it always so in plants; for in reality there are two forms of differentiation occurring more or less at the same time. One we may call *anatomical differentiation* or *morphogenesis*, and the other, *histological differentiation*, or more briefly, *histogenesis*.

During the periods of cell division and growth the cells do not all divide with equal frequency, nor do they all enlarge to the same extent. When the cells tend to arrange themselves in layers, as they do in animals, this inequality of growth causes foldings, the folds may fuse together, and old connections may dissolve. In this way unequal division and growth of the cells, resulting in folding, fusions, and separations, cause a differentiation of the mass of the ovum, whereby the areas are determined which shall include the rudiments of the various organs. In the embryo chick, for example, one may see the boundaries of the central nervous system, the notochord, the heart, etc., while the cells composing these rudiments are still in the most embryonic condition and cell division is going on rapidly. Thus, morphogenesis begins in very early stages of development, and precedes the process of histogenesis, which results in the modification of the cells so that they may form the tissues appropriate to the organs or parts of organs in which they lie. (Further details in regard to the facts of differentiation may be found in the articles *Area Embryonalis*, *Gastrula*, *Germ Layers*, *Segmentation of the Ovum*, etc.)

When we come to consider the conditions under which individual differentiation takes place, we see at once that these may be divided into two categories. For example, we may take an egg of a sea urchin and an egg of a star-fish, small transparent eggs not very different in size or general appearance and yet sufficiently unlike to be easily recognized. These, placed together in a bowl of clean sea water of the necessary temperature, and containing sufficient oxygen, will proceed to develop into larvæ; and, although the conditions of the environment are exactly alike for both eggs, one will become the larva of a sea urchin and the other the larva of a star-fish, according to the source of the egg. Or, again, consider a new-born litter of puppies. They are out of the same bitch, have been sired by the same dog, have undergone development at the same time in the same uterus. Yet these puppies will be sufficiently different so that each one may be recognized easily. On the other hand, any puppy in this litter will resemble the others and both parents more closely than will any puppy out of a similar litter dropped by any other bitch and sired by another dog. It is evident that there is something inherent in the germ cell that causes differentiation to proceed in a certain way more or less independently of surrounding conditions. Moreover, the resulting peculiarities of the offspring are correlated with the peculiarities of the parents at the corresponding stages of development; but the correlation is not perfect.

That the course of differentiation is not entirely independent of external conditions, but, on the contrary, is strongly influenced by them, may be shown by a number of experiments. For example, take seeds of two kinds of plants, say a bean and a petunia, and plant them side by side under the same conditions of soil, temperature, and moisture, and exclude all light. The seedlings will develop with long, slender stems, and small, yellow leaves. Seedlings of the same plants grown in full sunlight, other conditions being the same, will have shorter and thicker stems, and larger dark-

green leaves. Here we see that seedlings of two kinds of plant have certain characteristics in common which are correlated with the presence or absence of light while differentiation is in progress. Nevertheless in each case one plant is always a bean and the other a petunia, according to the seed from which it has arisen.

We see, then, that differentiation is influenced by two sets of factors—an internal and an external. The correlation between parent and offspring that is associated with the *internal* factor is what is ordinarily meant by heredity, and as various theories of heredity involve a consideration of the internal factors of differentiation, they will be most conveniently discussed mainly under that title (see article *Heredity*).

The study of the *external* factors which affect the course of growth and differentiation is a branch of biological science, called experimental morphology, developmental mechanics, or the physiology of development.

A few experiments may be mentioned to illustrate the methods that have been employed in attempts to ascertain in what way external conditions affect the processes of differentiation. The experiments will be classified according to the external condition that has been investigated.

*Gravity.*—A number of experiments have been made which show that in some animals the planes of cleavage in the early stages of the division of the egg are determined by the direction of the force of gravity. For example, Pflüger found that if the egg of a frog be fixed so as to prevent rotation, the first two cleavage planes would be vertical in whatever position the egg might be placed, and the third cleavage is generally at right angles to these and nearer the pole of the egg which is held uppermost. In order to obtain perfect embryos, however, it is necessary to have some part of the black hemisphere on the upper side.

It is impossible, of course, to increase the force of gravity. But the same effect may be obtained by placing an object in a centrifugal machine. Hertwig found that by rotating frog's eggs in a centrifugal machine he was able to change the style of cleavage from a holoblastic to a more or less mesoblastic type (see article *Segmentation of the Ovum*), so that at the end of twenty-four hours the egg would resemble a hen's egg in having a blastoderm consisting of small cells enclosing a blastocœl and a large undivided yolk containing a few nuclei which lie close under the blastoderm.

Loeb found that the direction of gravity is a factor in determining the differentiation of parts in certain hydroids. Thus, part of a stem of Antennularia being suspended in its normal position in sea water, a new stem will grow out from the upper end and new stolons will appear at the lower end. But let the position be reversed. Then the base, which is now uppermost, will produce the new stem, and stolons will grow from the apex, which is pointing downward. The effect of gravity is still further shown by placing a piece of the hydroid in a horizontal position. Then the ends of the lateral branches on the lower side grow out in the form of stolons, while new stems appear on the upper side.

*Contact.*—Contact with foreign bodies has been found to influence the differentiation of tissues in the hydroids.

Experimenting with Margeliss and Pennaria, Loeb found that parts of the stem in contact with the glass of the aquarium, even the apical end, would produce stolons; while all parts freely surrounded by sea water would produce hydranths. Similarly, Miss Peebles discovered that pieces of the stalk of Hydractinia and Podocoryne form stolons instead of hydranths if left undisturbed in contact with some hard substance.

When the cut surfaces of hydroid stems, either of the same individual, or of different individuals of the same species, or of different species, are held in contact, they may unite and form a graft, as in plants; and Crampton has shown that the same thing may be done with the pupæ of moths.

*Stress and Strain.*—Mürthle has shown that a certain amount of pressure and strain is necessary for the proper development of bone. Hermann von Meyer and Culmann discovered that the lamellæ in the spongy portions of the long bones of mammals are arranged with definite relation to the direction of the stresses to which the bones are normally subjected; and Julius Wolff found that, when the direction of stress is changed as the result of dislocation or disease, the lamellæ that are no longer in the lines of pressure or strain will dwindle and new ones will be formed in the positions where they are needed.

*Light.*—On the higher green plants prolonged darkness induces abnormal growth. The stems are not only greatly elongated, but the supporting tissues are imperfectly developed, so that the stems are soft and tender. The leaves are small and narrow and not fully extended. Even partial shading may result in alteration of the histological structure of leaves, as Stahl found from the study of the leaves of beech trees. A leaf that is fully exposed to the sunlight has under the epidermis on the upper side a layer of very high and narrow palisade cells closely packed together; below this there are one or two layers of similar cells, and the lower third of the leaf is occupied by a rather compact spongy parenchyma. In a leaf that has grown in deep shade, on the other hand, there is but a single layer of short conical palisade cells separated by wide interstitial spaces; and more than half the thickness of the leaf is due to a layer of loosely connected star-shaped parenchyma cells. Between these two extremes various intermediate grades may be found according to the amount of light received by the leaf.

There is not much known about the effect of light upon differentiation in animals; but Poulton found that the color of the pupæ of certain butterflies depends upon the amount of light reflected from surrounding objects at the time that the caterpillar becomes fixed; and Loeb and Miss Peebles found that the presence or absence of light has a certain amount of effect upon the regeneration of the hydranths upon the cut stems of hydroids.

*Temperature.*—That heat has a marked effect upon the rate of growth is well known, but little has been ascertained as to what effect it may have upon differentiation. We have, however, the interesting experiments of Weismann and of Edwards, who have shown that in several species of butterflies, where there are several broods in the course of the year with different markings, the differences of color depend upon the temperature to which the pupa has been subjected.

While changes of temperature affect both growth and differentiation, the two processes may not be affected to the same degree. The optimum temperature for the incubation of a hen's egg is about 38° C. In a series of experiments in which the eggs were kept for six days, at a temperature of 24.5° C., C. L. Edwards observed that the average diameter of the blastoderm increased from 4.4 millimeters to 6.9 millimeters, but the differentiation of the primitive streak was totally inhibited. According to Kaestner, the limiting temperatures between which normal development may occur are 35° and 39° C. If eggs are kept at temperatures above or below this range, the embryos are apt to be abnormal. The writer once while incubating eggs for class-work had the temperature of the incubator accidentally rise to above 39° C. and remain there for several days. The embryos that resulted were for the most part double monsters.

*Chemical.*—For normal development a normal chemical environment is of the greatest importance. The one substance universally important for all vital processes is oxygen. Exclusion of oxygen will

cause arrest of development and death sooner or later, the time depending on the species and the stage of development. Normal atmospheric pressure is about equal to that of a column of mercury 760 millimeters high. Giacomini found that, when the pressure of the air is reduced to 600 millimeters, chick embryos develop abnormally—optic vesicles, blood capillaries, and hemoglobin fail to appear and the medullary tube and the amnion are abnormal. But if incubated in an atmosphere of pure oxygen at this pressure, the embryos were completely normal. Further, it has been suggested by several authors that the normal movements of the cells in development may be in some cases a chemotactic response to oxygen.

Of other substances a mere trace may be all that is necessary for normal development that will not occur in its absence. And, on the other hand, the presence of some substance not normally present may so disarrange the processes of development as materially to alter the character of the organism. Thus a trace of a soluble iron salt is necessary for the development of a green plant. Without it, not only is the green coloring matter absent, but the protoplasmic chlorophyll bodies also fail to appear. Knop experimented with Indian corn, treating it with sulphite of magnesium, and he obtained plants so modified that they had lost the distinctive characters of the genus Zea.

Wagner, Gies, and Kassowitz, by feeding young animals with minute doses of phosphorus (0.0015 gram) and arsenic (0.0005 to 0.001 gram), produced striking alterations in the formation of the bones. The normal fusion of the cartilage with the young bone was hindered, and in the epiphyses, instead of spongy bone, there was produced a very peculiar compact bone. In the shafts of the long bones the formation of the medullary space was hindered so that the walls of the bone became very thick and heavy.

The Pluteus larva of a sea urchin is normally provided with eight arms, which carry a band of cilia and serve as locomotor organs, and these arms are supported by a calcareous skeleton. Herbst found that a trace of potassium nitrate added to the sea water in which the larvæ are reared will prevent the formation of both skeleton and arms. Pouchet and Chabry obtained the same result by the more obvious method of rearing the larvæ in sea water from which the calcium salts had been removed. Of course, in this case the skeleton could not form from lack of material, but it is interesting to note that where the skeleton failed the arms failed also.

Another and more remarkable modification of the Pluteus was obtained by Herbst by adding a trace of lithium chloride to the sea water. In this case, the so-called lithium larva, the endoderm turned outward, instead of being invaginated in the normal way. Loeb obtained the same result by simply diluting the sea water, which would seem to indicate that the action of the lithium salt in some way interferes with the normal osmotic properties of the cells.

Finally we may mention the remarkable experiments made many years ago by Schmankewitsch upon Artemia, a small crustacean inhabiting the brine of salt works. By rearing these creatures for a number of generations in water of different degrees of salinity he was able to obtain diverse forms which had been regarded formerly as three distinct species, and one of them had been given a separate generic name.

*Mixed Conditions.*—There are cases in which it can be shown that change of environment induces a change in the organism, but the nature of the former change is so complex that the exact factors cannot be determined. For example, aquatic plants have certain characteristics of structure that distinguish them at once from land plants. Now there are certain plants that live with their stems partly in water and partly in air. In such plants the submerged portions have the character of aquatic plants, while the aërial portions have that of land plants. Here it is impossible to tell how much of the difference is due to the chemical or mechanical effect of the water, the freer access of oxygen, differences in light, temperature, etc.

*Internal Conditions.*—While the strictly internal factors of differentiation are more conveniently discussed in connection with the problems of Heredity (*q. v.*), some of the influences that lie wholly within the organism should be considered here.

Comparing the influence that external factors exert upon embryogenesis with the inner powers of development of the animal egg, Przibram (1907) says that, although chemical composition, moisture, and concentration of the surrounding medium, heat, and to a certain extent, gravity and light are necessary for normal development; nevertheless, external conditions can vary widely without stopping the typical evolution of the animal form. Moreover, the natural conditions are not always the most favorable. In fact, the influence of external factors passes into the background when compared to the inner factors of development. These express themselves in a nearly complete self-differentiation, in the sense that Roux uses the term.

Leaving the undoubtedly great influence of the cell nucleus to be discussed with the theories of heredity, we may consider other internal factors of differentiation under the following heads: Organ-forming substances, internal secretions, contact with other organs, imponderable influences.

*Organ-forming Substances.*—In the cytoplasm of the egg of some of the lower animals, as in the mollusc, Dentalium (Wilson), and in the tunicate, Cynthia (Conklin), there are certain visible substances that in the normal egg have a certain definite location and which, during cleavage, are distributed to cells that give rise to certain organs. If these cells are separated experimentally, the embryo fails to develop the corresponding organs. Such experiments seem to confirm the theory of His that differentiation is due to the presence of organ-forming substances. They cease to be hypothetical, for they are visible and can be subjected to experiment. But Morgan, working with the eggs of another mollusc, Cumingia, and Lillie, with the eggs of a worm, Chætopterus, carried experimentation farther and showed that these visible substances in the egg can be redistributed by means of the centrifuge without disturbing the normal cause of development. Therefore, if there are organ-forming substances in the egg, they are probably not identical with these formed substances that can be seen, but are to be sought in the living substance, either the apparently homogeneous cytoplasm or the nucleus.

*Internal Secretions.*—In physiology and medicine great importance is attached to the action of the substances produced by the ductless glands and other organs. These substances, to which Bayliss and Starling gave the name *hormones*, are not secreted through ducts, but pass directly into the fluids of the body. It is well known that substances of this class have a profound influence upon growth and that they may hasten or retard differentiation. The familiar effects of the removal of the genital glands are attributed to the hormones produced by these organs. Gudernatsch (1912) fed tadpoles with various mammalian organs, and found they had certain influences on growth and differentiation. The thyroid caused precocious differentiation but suppressed growth, while the thymus had the opposite effect, causing rapid growth and postponing the metamorphosis, or inhibiting it completely. Extensive reviews of this subject are given by Hirsch (1911) and by B. Wolff (1913). Hirsch concludes that it is doubtful whether the hormones act directly on other organs or through the nervous system. Wolff finds very little positive

evidence of an influence exerted by the hormone-secreting glands of the fetus upon its development. In fact it is possible that these glands may be entirely functionless during intrauterine life.

*Contact.*—The notion that the differentiation of one part may be influenced by contact with adjoining parts was developed by Driesch and O. Hertwig with reference to the fate of the blastomeres in the segmenting egg. The organ to which a given blastomere may give rise depends upon its position in the whole embryo, or as Dreisch expresses it, the prospective value of a blastomere is a function of its position.

Minot has expressed the view that the vestigial organs, so commonly met with in higher animals, may not be so useless as they seem to be. Thus the gill clefts, present in the embryos of all vertebrates, although never functional in the Amniotes, may be necessary for the normal development of the pharyngeal nerves and other structures.

The view that the lens of the eye is developed only when the ectoderm is stimulated by contact with the optic cup, was originated by Spemann and by Herbst, and later was brilliantly confirmed by the experiments of W. H. Lewis. Stockard (1910) finds, however, that in fish embryos the development of the optic cup can be totally suppressed by treatment with anesthetics, and yet in such embryos perfect crystalline lenses may arise from the ectoderm without any direct contact with the optic cup or any other part of the nervous system.

*Imponderable Influences.*—As the results of experiments upon primitive animals, chiefly Planarians, Child (1913) has attempted a dynamical explanation of differentiation. He finds in these worms that, under normal conditions, the rate of reaction to external stimuli is greater at the anterior end and decreases posteriorly. If a worm be cut into pieces some of the pieces may develop into whole worms, but "No piece of the body can produce any part characteristic of a level anterior to that from which it was taken, unless a head begins to form first." "The reaction system which gives rise to the head or apical region is the fundamental reaction system of the species. And in this system the formation of the cephalic or apical region of the central nervous system . . . is the fundamental feature." "Probably in all organisms with one or more definite axes, only the capacity to form this fundamental reaction system need be inherited in order to produce a whole with specific characteristics." This view is interesting and in harmony with experimental evidence, but it must be said it is rather hard to visualize.

Driesch, in his more recent writings (1908), has abandoned the attempt to formulate a mechanistic theory of differentiation and has become the principal expounder of a new vitalism. For him biology is no longer applied physics and chemistry, another factor is required to explain the animal form. A vitalistic feature is needed, and this he invokes under the name *Entelechy*, a term borrowed from Aristotle. Entelechy has nothing of a psychical nature, it is not a substance, it is not a kind of energy, it is not quantitative, nor does it possess any seat. It is just an "order of relation and nothing else." Nevertheless, entelechy can act and its acts are purposeful. It acts by suspending and setting free reactions. There is nothing like it in inorganic nature. There are different kinds of entelechies at work in the organism—one generating differentiation, another controlling instincts and actions, and others of subordinate rank. But all have originated from the primordial one. Entelechy is conceived only, it cannot be imagined. "Life is understood by the concept of entelechy just as well as is inorganic nature by the concepts of energy, force, mass, etc. There is no need of further 'explanation.'" Driesch claims for his theory that it is not metaphysical, but is founded on experiment. If not metaphysical, it is at any rate frankly philosophical. It goes beyond the limits of science, and, for that reason, has not found much favor with biologists.

ROBERT PAYNE BIGELOW.

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**Digalen** is a proprietary preparation of digitalis said to be a soluble amorphous digitoxin; but this claim has been denied. It is also claimed to be non-cumulative in ordinary doses (seventeen minims, 1 c.c. three times a day); but caution should be displayed in either advancing or crediting such a claim in regard to any preparation of digitalis. For action and uses of digitoxin and the other glucosides of digitalis, see *Digitalis*. R. J. E. SCOTT.

**Digenea.**—A subdivision of the border *Malacotylea* among the flukes, in which the development shows an alternation of generations. The first form is a cysticercus, usually found in a snail or some other invertebrate. Often the larva passes through two secondary hosts before reaching maturity. This group contains many human parasites; the genera are listed in the following table:

Family, Paramphistomidæ—*Gastrodiscus, Cladorchis.*
Family, Fasciolidæ—*Fasciola, Fascioletta, Agamodistomum, Fasciolopsis, Opisthorchis, Clonorchis, Metorchis, Paragonimus, Hetrophyes, Dicrocœlium.*
Family, Monostomidæ— *Monostomulum.*
Family, Schistosomidæ—*Schistosoma.*

See *Trematoda*. A. S. PEARSE.

**Digestants.**—The process of digestion includes both the mechanical disintegration of foods and their chemical preparation for absorption and use by the body. Digestants are more or less artificial aids to the physiological processes of digestion either applied to nutrients prior to ingestion (predigestion) or administered internally. In the broadest sense, various industrial processes, as the manufacture of flours and meals, which remove indigestible material and facilitate mastication and softening of foods, the cutting and comminution of foods outside the body, the combination of foods and cooking, may be considered as digestant factors. In the ordinary sense, digestants are chemical substances, mainly ferments, more or less analogous to those of the human body.

As man has, even from prehistoric times, begun the digestion of most proteins, especially those of

meats, from the state of albumin coagulated by heat, cooking may be considered a predigestant, even in a technical sense. So too, his salivary ferment, ptyalin, has long lapsed into a state of actual weakness or of quantitative insufficiency such that it can no longer hydrolyze raw starch except in minimal quantity, while the corresponding ferment of monkeys, squirrels, and other animals subsisting largely on raw seeds, is almost as active as amylopsin. Thus the rupture, by cooking, of the cellulose wall of starch granules and the change of starch from the raw to the soluble form, may also properly be considered as digestant. In the crust of bread, in toast, and certain cereal preparations, cooking converts starch into some stage of dextrin. In the malting of grains, diastase converts starch still further, to the stage of maltose. Artificially prepared dextrose may be considered a still further instance of predigestion, up to the point of absorption and such small quantities of glycogen as are consumed in liver, horse-meat, and certain crustacea, have even passed this point. In the action of rennet upon milk, whether the curd or whey or both, as in junket, are employed, we also have a digestant action illustrated. Yeast, by converting part of the starch of bread into carbon dioxide both facilitates cooking and tends to separate the mass into discrete portions, thus, even after mastication, facilitating mechanical digestive processes in the stomach and intestine. It is somewhat doubtful how far the enzyme activities of bacteria duplicate the physiological enzyme processes and, except in the ripening of cheese, the appreciable action of bacteria upon food stuffs is undesirable, although it presents many analogies to true digestion.

The combination of albumin with acids and alkalies is a step in gastric and intestinal digestion, respectively, and the reaction resulting facilitates further digestion. However, unless gastric digestion is eliminated by achylia or, at least, achlorhydria, or by some surgical short-circuiting of the stomach, a change of reaction is practically limited to the acid type and to hydrochloric acid combination, in particular, as conforming to the normal physiologic process. Ehrlich has calculated the amounts of hydrochloric acid necessary to combine with the albumin of various foods as follows: per 100 grams or cubic centimeters. The amounts stated should be multiplied by ten to reduce the acid to the official dilute form. The acid should be added gradually, thoroughly mixed with the food and should be allowed to act for at least half an hour at about the body temperature. This method of predigestion is particularly applicable to cases of marked hypochlorhydria, not amounting to actual achylia, in which latter the gastric digestion is ignored, reliance being placed either on the persistence of normal intestinal digestion or upon a reinforcement, or on predigestion in the ordinary sense, or the use of vegetable digestants.

| | |
|---|---|
| Milk | 0.32 to 0.42 |
| Boiled beef | 2.0 |
| Boiled mutton | 1.9 |
| Boiled veal | 2.2 |
| Boiled pork | 1.6 |
| Boiled sweet bread | 0.9 |
| Boiled calf brain | 0.65 |
| Boiled ham | 1.9 |
| Raw ham | 1.9 |
| Liver sausage | 0.8 |
| Cervelat sausage | 1.1 |
| Mettwurst | 1.0 |
| Blood sausage | 0.3 |
| Graham bread | 0.3 |
| Pumpernickel | 0.7 |
| Wheat bread | 0.3 |
| Rye bread | 0.5 |
| Swiss cheese | 2.6 |
| Fromage de Brie | 1.3 |
| Edam cheese | 1.4 |
| Roquefort cheese | 2.1 |
| German beer | 0.07 to 0.15 |

When hydrochloric acid is deficient but the gastric juice, after adding this acid, digests egg albumin or other test substance, the acid itself should usually be supplied, in doses of 1 c.c. of the official dilute acid, well diluted, about one hour after meals, repeating in half to one hour as indicated. Acidol, an organic combination liberating hydrochloric acid gradually, may also be employed.

In the use of digestants, a general choice must be made between predigestion, special methods of feeding, as by nutrient enemata, fistulæ, inunction, and hypodermatic injection which is nearly limited to water, salts, and dextrose, and finally, the addition of a digestant to the ingested food. As a rule, in high fever from any cause the food should be simple, liquid or pultaceous, and hence practically mainly limited to milk, eggs, and soft cereal substances. Owing to the usual inhibition of secretory activity, predigestion is usually chosen, incubating either the milk alone or its combination for about an hour, at approximately body temperature, and employing sodium bicarbonate and some form of pancreatic extract as the digestant. The process is stopped short of full peptonization on account of the bitterness of peptones and, unless intended for immediate use, further digestion and fermentation are checked by refrigeration in the ice-box. The same choice is made in general states of prostration from any cause, especially at the extremes of life.

In the case of serious hemorrhage from the stomach, duodenum, or small intestine generally, or if there is an ulcer or other serious lesion such that the passage of food through the alimentary canal is a source of danger or an impediment to healing, it is usually best to withhold food altogether or to nourish by nutrient enemata.

If gastrostomy or enterostomy high in the small intestine has been performed on account of a proximal obstruction or lesion requiring physiologic rest, predigestion should usually include the normal processes of mastication and insalivation and, if intestinal digestion is fairly normal, no strictly artificial digestant need be employed. When a gastroenterostomy has been established, it is usually held that either the original condition or the regurgitation of intestinal secretions into the stomach, vitiate gastric digestion, so that any further predigestion or administration of digestants should be supplementary to pancreatic digestion. It is even held that unless the physiological process of gastric digestion either has been or ought to be inhibited, gastroenterostomy is not justifiable. In spite of these theoretic views, many cases exist in which the gastric digestive process is not seriously affected, and even those in which the gastroenterostomy opening admits very little material from the intestine while the discharge from the stomach continues to be through the pylorus or resumes its passage through the pylorus. In these cases, predigestion or administration of digestants, should depend upon the actual features of the case.

It may be stated, as a general principle, that adequate nutrition depends mainly on the secretion of the pancreas and small intestine, even the hepatic secretion being of subsidiary value, and on opportunities for digestion and absorption afforded in the small intestine. Hence, various important positive and negative corollaries follow:

1. Marasmus and ultimate death ensue if half, more or less, of the small intestine is resected or in any way short circuited.

2. Practically complete obstruction at any point above the pylorus, unless obviated surgically, so as to allow the entrance of food into and its passage through the intestine, results in death about as soon as by actual starvation. Hence, no form of predigestion or assistance by digestants is efficient, even if the stomach can be employed without notable interference on account of the lesion.

3. Nutrition by enema, with or without predigestion or addition of digestants, does not afford sufficient opportunity for digestion and absorption, although many believe that approximately half or one-third of the total caloric requirement of the body may be thus supplied and an emergency may be tided over or life may be prolonged.

4. On the other hand, physiological failure of the stomach—achylia—or any operative exclusion of the alimentary canal above the pylorus or below the ileocecal valve, is compatible with nearly perfect nutrition, if the small intestine and its tributary glands, especially the pancreas, are approximately normal in function, and provided, of course, that the access of nutrients so as to pass through the small intestine, at least, is allowed.

5. Whether reliance must obviously be placed on the small intestine and its tributary glands alone, or whether there is no gross mechanic interference with the passage of food throughout the entire alimentary canal, nutrition depends almost entirely upon the small intestine and its tributary glands, especially the pancreas. Even if the alimentary processes above the pylorus and below the ileocecal valve are entirely normal, failure of digestion in the small intestine results in death. Minor degrees of such failure may be compensated by the use of digestants, before or after ingestion, but serious degrees are fatal. In certain cases of Addison's disease, pancreatic achylia often associated with gastric achylia exists. Various gross lesions of the pancreas, obstruction to its duct (or ducts) and extensive necrosis of the small intestine, are necessarily fatal.

6. In differentiating the factors of intestinal digestion, the following statements may be made: The bile acts only as an alkali and diluent and as facilitating the splitting and absorption of fats. While hepatic and biliary diseases may seriously interfere with nutrition and cause death, the direct action of the secretion of the liver on digestion, is not of vital importance and may be compensated by the administration of mild alkalies, such as sodium bicarbonate, water, and inspissated bile or pure biliary salts. We have no detailed knowledge of the physiology of the intestinal glands and clinical methods of determining their individual activity such as would enable us to discriminate sharply and weigh the relative importance of failure of the intrinsic functions of the small intestine, although extracts of the small intestine may be used empirically both to stimulate peristalsis and to activate trypsin. All things considered, digestion may be considered to have its crucial point in the pancreas and while minor failures of its secretion may be supplemented, serious interference with its functions is quite rapidly fatal.

Carbohydrate Digestion.—Ptyalin is not a ferment of great nutritive importance as it digests only cooked starches, and usually these only to a minor degree on account of hurried mastication and insalivation and the inhibition of its action by the rather rapid development of gastric acidity. It has been shown, however, that with prolonged mastication, 100 grams of starch may be converted at a meal, thus allowing for complete starch digestion, up to the stage of maltose. In passing, it may be remarked that even in marked hyperchlorhydria, some sugar is almost always formed. Ewald states that, even in dental caries, diphtheria, carcinoma of the tongue, etc., he has never found ptyalin lacking. Neither has the writer, even in cases of mumps. Schlesinger found that the maximum starch conversion in pathologic cases was about the same as in health though the minimum was only about seventy-five per cent. of the normal. Hence, it cannot be said that there is ever an indication for artificially supplying ptyalin, although, as stated, it should be supplied in the natural manner, when food is to be introduced through a fistula.

Ferments analogous to ptyalin are formed in the process of malting and may be administered as official or unofficial forms of malt, and as commercially pure diastase. So-called starch indigestion usually implies that, in spite of sufficient ptyalin or amylopsin, concomitant bacterial activity causes an undue amount of fermentation of carbohydrates and consequent loss of digestible material. It may be, to some degree, offset by the administration of diastase in various forms but is rather to be met by dietetic limitation, sterilization of foods, of the teeth and buccal cavity, tonsils, etc., by lavage, catharsis and antiseptics.

Quantitative deficiency of amylopsin can scarcely be estimated with any degree of accuracy. If the feces show undue remains of starch, allowing for the inevitable escape of starch inclosed in dense cellulose structures, as in unmasticated peas, beans and corn, imperfectly cooked potato, raw radishes, nuts, etc., or if there are other indications of general pancreatic failure, amylopsin may be supplied, though it cannot be practically separated from other pancreatic ferments. Or, other digestants such as diastase and the omnidigestant vegetable extracts, may be employed.

An important point in carbohydrate digestion is the splitting of the double hexose, maltose produced by ptyalin and amylopsin or of the double hexoses, galactose (milk sugar) and saccharose (cane, maple or beet sugar) commonly taken as such, into their component simple hexoses prior to absorption. This splitting is accomplished by invert ferments secreted by the stomach and intestine. Very little is known of their presence or absence. It may be that the favorable action of pepsin preparations in cases in which there is no obvious indication for supplying proteolytic ferments, or of the vegetable digestants indiscriminately used in so-called starch indigestion, is due to supplementing the inversion of double hexoses.

Fat Digestion.—Fat is never digested to any practical degree in the stomach unless the conditions are so abnormal as to render it practically a part of the intestine. It is never perfectly digested, absolutely and relatively considerable amounts being wasted if more than 150 grams are taken and relatively considerable amounts if less than ten to twenty grams are taken since, in the latter case, the fat is included in indigestible tissues. Fat can be entirely eliminated without harm, since it may be formed from either protein or carbohydrate. Hence, more than for either protein or carbohydrate, fat indigestion is to be met by limitation of diet instead of a reinforcement of digestive power. So, too, fat indigestion can often be ameliorated simply by selecting fats of relatively low melting-point, as olive oil, butter, and cream and by having it well mixed with other foods or emulsified, as in Mayonnaise.

Fecal analyses furnish better criteria of fat than of either protein or carbohydrate digestion though it is difficult to distinguish failure of steapsin and, indeed, identical splitting and recombination of fats into soaps and glycerin occur at the body temperature without a fat-splitting ferment, in an alkaline medium. However, if considerable quantities of neutral fats persist in the feces—providing the ingestion is within physiological limits—the administration of pancreatic extract is indicated (see previous remarks as to impracticability of separating the various pancreatic ferments). On the other hand, if the fecal fats are mainly in the form of soaps and fatty-acid crystals we may consider the special indication to be biliary salts to expedite absorption and alkalies, respectively.

Protein Digestion.—Pepsin is originally secreted as a pro-enzyme, the process being completed if there is even a slight excess of free hydrochloric acid. Insufficient protein digestion in the stomach usually depends upon lack of the latter substance, the genuine failure of ferments being rare (achylia), probably not

occurring in more than one per cent. if, indeed more than 1 : 1,000 of the cases in which pepsin is employed. Alcoholic essences of pepsin also inhibit peptic digestion though the inhibition is probably prevented by dilution with the gastric contents. However, it must be admitted that in spite of theoretic objections, namely, the rarity of true ferment failure and the principle that ferments act almost irrespectively of their quantity, a large excess of pepsin does facilitate protein digestion, even in incubation experiments.

Failure of protein digestion in the intestine is not directly demonstrable except in extreme cases and the various tests leading to inferences along this line are too complicated to be discussed here. The theoretic indication is the administration of trypsin which cannot be separated from pancreatic extract. Like pepsin, it is secreted as a pro-enzyme, being activated by enterokinase, now available as an intestinal extract. While there is no absolute proof nor *a priori* principle, it may usually be considered that gastric secretion will not persist in a normal state if pancreatic secretion is seriously impaired. Hence, in general, pancreatin should not be administered except in cases at least approaching achylia gastrica. Moreover, as the pancreatic extracts are destroyed or decidedly weakened by exposure to the acid gastric juice, they should not be administered during active, relatively normal gastric digestion, unless inclosed in keratin or salol which does not dissolve to any degree until the alkaline intestinal juices are reached. Like starch indigestion, protein indigestion is a term often applied rather to concomitant bacterial destruction of protein than to an actual lack of peptic or tryptic power and the condition is to be treated accordingly.

Pepsin is commonly derived from the stomach of the pig, as most closely resembling man in omnivorous habits of diet and physiology of digestion. It may, however, be derived from a variety of animals and there is both theoretic and clinical reason for preferring an extract derived from the stomach of a carnivorous animal, such as the dog. The gastric juice of the pig, dog, or other animal, obtained through a fistula after stimulation of the jejune stomach, may also be employed. Rennin, the milk coagulating ferment, cannot be separated from pepsin and there are some who hold that there is really but one ferment acting in a double capacity. Commercial rennet is obtained from the stomach of the calf as physiologically most active in the coagulation of the milk of commerce but it also has proteolytic power, though less than that of extracts from pigs' or dogs' stomachs.

Pancreatin is a more or less concentrated and purified extract of pancreas, it being impossible to separate the various enzymes. Ingluvin, a proteolytic ferment derived from fowls has been used to some degree as a digestant and it is obvious that extracts of digestive glands of any animal whose digestive physiology is analogous to that of man, might be employed.

Several plants are markedly carnivorous, even possessing special organs for attracting and catching insects either by sticky secretions or by motile, trap-like modifications of leaves. Among these are the sundew, Venus's fly-trap, and saracenia. Little if any attempt has been made to use these plants for the preparation of therapeutic digestants.

The favorite digestant of vegetable origin is derived from the pawpaw, carica papaya, and sold under various trade names, as papain, papoid, caroid, etc. It is active in either acid, alkaline, or neutral medium and digests starch as well as protein. Bromelin, a similar ferment, has been isolated from the pine-apple and several other bromelaceæ. Possibly because the fruit is usually gathered green and allowed to ripen off the plant, the writer has been unable to demonstrate a proteolytic action in the juice.

The various proteolytic ferments, especially those of vegetable origin, have been used to digest diphtheritic membranes and necrotic tissues. An artificial gastric juice or even the filtrate from active stomach contents may be employed in carbuncles, etc.

Generally, ferments do not attack living tissues, at least not those of full vitality and with which they naturally come into contact. However, in diarrhea, undestroyed trypsin often causes excoriation of the anus, while gastric and upper intestinal ulcers are undoubtedly due largely to digestion of areas either directly necrotic from vascular occlusion, or of enfeebled resistance on account of transient spastic diminution of blood supply. Foreign ferments theoretically have a greater activity and while there is no clinical proof of such results, it is possible that the use of active, carnivorous ferments or even strong vegetable ferments may determine the formation of a peptic ulcer in those predisposed. Certain strongly proteolytic bacteria destroy living tissues, as noted in chancroid and phagedena. The obstinate persistence of salivary fistulæ suggests that there may be a proteolytic action, analogous to that claimed for certain diastases of vegetable origin, in addition to the admitted amylolytic action.

*Dosage.*—The various animal and vegetable ferments are commonly employed in doses of 1 to 4 grains, it being assumed that ferment action is not directly proportionate to the quantity of the ferment. It should be understood, however, that the various ferments are probably never obtained in a state of absolute purity and that commercial ferments are merely extracts or concentrations, adequately freed from inert substances. A. L. Benedict.

**Digestion, Disorders of.**—See *Dyspepsia*.

**Digestive Tract.**—The stomach (ventriculus) and esophagus will be considered separately. The present article includes the remaining portion of the digestive tract; the small intestine (intestinum tenue), the large intestine (intestinum crassum), and the rectum (intestinum rectum).

The intestinum tenue commences at the pylorus and, after a series of complicated convolutions, terminates in the intestinum crassum. Its average length in the adult male is 6.8 meters; in the female it is about fifteen centimeters longer. Its greatest diameter is in the duodenum; it gradually diminishes in size as it approaches its termination.

The intestinum tenue is divided into the duodenum and the intestinum tenue mesenteriale. The duodenum in the adult does not possess a mesentery: consequently it does not belong to the "mesenterial small intestine."

The duodenum is the most fixed portion of the digestive tract and immediately follows the stomach. It is from twenty-five to thirty centimeters in length passing at the flexura duodenojejunalis into the jejunum.

Three types of duodena can be recognized: (1) the annular, found in the second half of fetal life and occasionally persisting in the adult; (2) the U-shaped, in which the pars inferior is very long; (3) the V-shaped, in which the pars descendens passes down almost vertically while the pars ascendens passes upward and somewhat to the left making an acute angle with the pars descendens; the pars horizontalis is wanting.

While the extent of the duodenum can be marked off by definite boundaries, the subdivision of the intestinum tenue mesenteriale into the intestinum jejunum and intestinum ileum is an arbitrary one. The upper one-third is called the jejunum and the lower two-thirds are called the ileum.

The intestinum crassum is divided into the intestinum cecum, the processus vermiformis, and colon. Measured from the root of the processus vermiformis to the beginning of the intestinum rectum, it is, in the adult male, about 1.4 meters in length; in the female it measures about five centimeters less. It

varies in diameter from three and one-half centimeters to seven centimeters without the extreme measurements indicating either dilatation or stenosis. Like the intestinum tenue it diminishes in diameter from above downward.

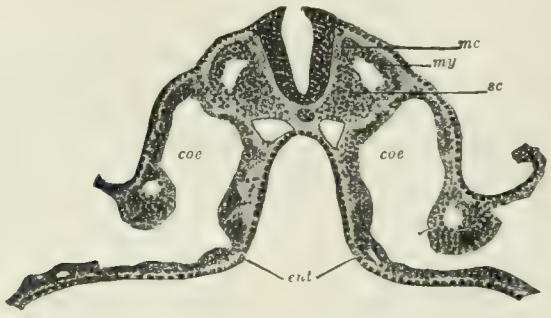



Fig. 1670.—Transverse Section of the Human Embryo of 2.4 mm. *ent*, Entoderm of yolk sac: the lines indicate the points of the splanchnopleuric layers which will fuse, cutting off the intestine from the cavity of the yolk sac; *my*, outer wall of mesodermic segment; *mc*, part of its wall which gives rise to the muscle-plate; *sc*, sclerotome; *coe*, celom. (After T. H. Bryce.)

The intestinum rectum begins at the middle of the third sacral vertebra and terminates at the anus. It is about 12.5 centimeters in length; in the lower portion it possesses a special dilatation, the ampulla recti, which may measure twenty-five centimeters in circumference or even more. The intestinum rectum is divided into the rectum proper and the pars analis recti.

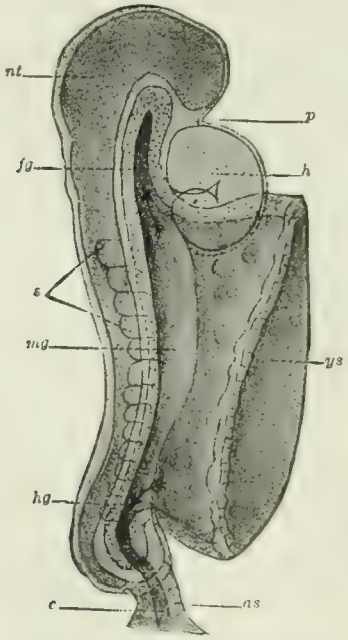



Fig. 1671.—Human Embryo, 2.5 mm. long. ×30. (After Kollman.) The yolk sac is cut away. The rudiment of the primitive intestines can be seen extending through the embryo. *as*, Allantois stalk; *c*, epithelial tube within the allantois stalk; *fg*, fore-gut; *h*, heart; *hg*, hind-gut; *mg*, mid-gut; *nt*, neural tube; *p*, mouth pit; *s*, somites; *ys*, yolk sac.

Development.—The alimentary tract arises from the endoderm, reinforced by the visceral layer of the mesoderm. The entoderm furnishes the epithelium of the entire alimentary tract and the organs arising from it: the lungs, the liver, and the pancreas. The visceral layer of the mesoderm, on the other hand, gives origin to the musculature, the connective-tissue layers, the mesentery, and the omentum.

By a process of folding there is gradually formed from these membranes, which are at first spread out flat, a tube which is broadly in contact with the dorsal wall of the embryo along nearly its entire length immediately ventral to the notochord (Fig. 1670). In this tube we can distinguish three divisions which have received the names of fore-, mid-, and hind-gut. Neither the fore-gut nor the hind-gut opens in the early stages of development to the exterior; each ends blindly.

During the earlier stages of development the mid-gut is connected with the yolk sac by a wide communication (Fig. 1671); as development progresses this communication becomes more and more constricted. This constriction is brought about by the growth caudal, on the one hand, of the fold that gave rise to the fore-gut; on the other hand, by the growth cephalad of the fold which formed the hind-gut. At the same time there is formed a lateral fold on either side of the embryo which extends along its axis and gradually bends around ventrally.

By the growth of these folds the previously wide communication of the mid-gut with the yolk sac becomes smaller and smaller until there finally remains only a narrow communication between the mid-gut and the yolk sac—the vitelline duct or ductus omphalo-entericus.

On the ventral side of the fore-gut the heart is situated, while from the hind-gut a diverticulum grows out which forms a thick-walled stalk. This stalk is known as the allantoic stalk, or the Bauchstiel of His. In man and other primates this diverticulum always remains narrow, but in the lower vertebrates it forms a free vesicle. Eventually by the continued growth of the folds mentioned above the vitelline duct and allantoic stalk become approximated, and

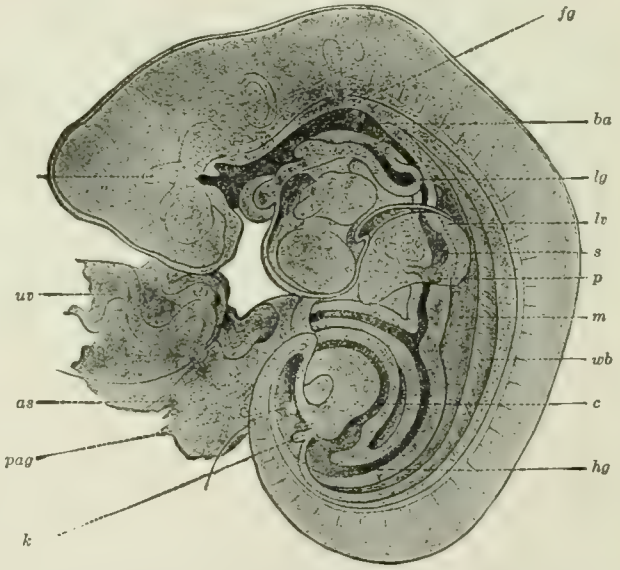



Fig. 1672.—Human Embryo, 5 mm. long. Sagittal section of a reconstruction. ×15. (After His.) *as*, Allantois stalk; *ba*, branchial arches; *c*, allantois canal; *fg*, fore-gut; *hg*, hind-gut; *k*, kidney; *lg*, lung; *lv*, liver; *m*, mesentery; *p*, pancreas; *pag*, post-anal gut; *s*, stomach; *uv*, umbilical vesicle; *wb*, Wolffian body.

there is thus formed the umbilical cord, which contains not only the above-mentioned structures, but also the umbilical arteries and vein.

In embryos 2 to 3 millimeters in length the alimentary tract is nearly straight (Fig. 1671). With the wheellike bending of the body of the embryo the head and tail approach each other and the entire

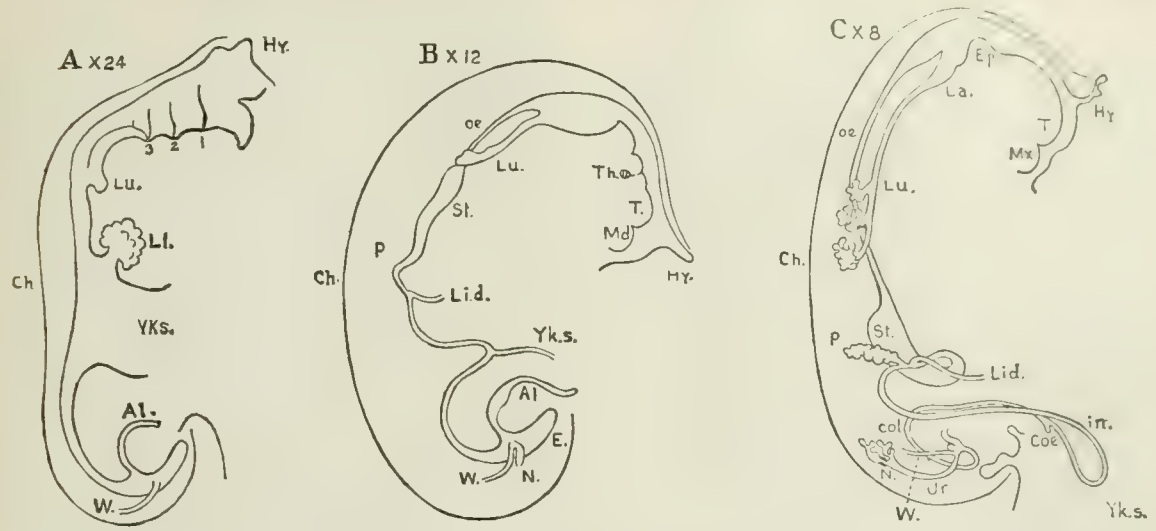



FIG. 1673.—Digestive Tracts of Three Human Embryos. *A*, Embryo of 4.2 mm.; *B*, embryo of 7 mm.; *C*, embryo of 13.8 mm. *Hy*, Hypophysis cerebri; 1, 2, 3, gill clefts; *Lu*, lungs; *Mx*, mandibula; *T*, tongue; *Th*, glandula thyroidea; *Ep*, epiglottis; *La*, larynx; *oe*, esophagus; *St*, ventriculus; *P*, pancreas; *Li*, hepar; *Li.d*, primitive duct of the liver; *Yk.s*, yolk sac; *Al*, allantois; *E*, end arm, or extension of the cloaca; *in*, intestinum tenue; *Coe*, cecum; *col*, colon; *N*, kidney; *Ur*, ureter; *W*, Wolffian duct; *ch*, notochord. (From Minot, after His.)

alimentary tract becomes bent together (Fig. 1672). With the increase in size of the embryo, the alimentary tube also lengthens, and we can now distinguish anteriorly a pharyngeal portion, while posteriorly to this, and extending as far as the rudiments of the liver and pancreas, is that part of the alimentary tube which gives origin to the esophagus, stomach, and

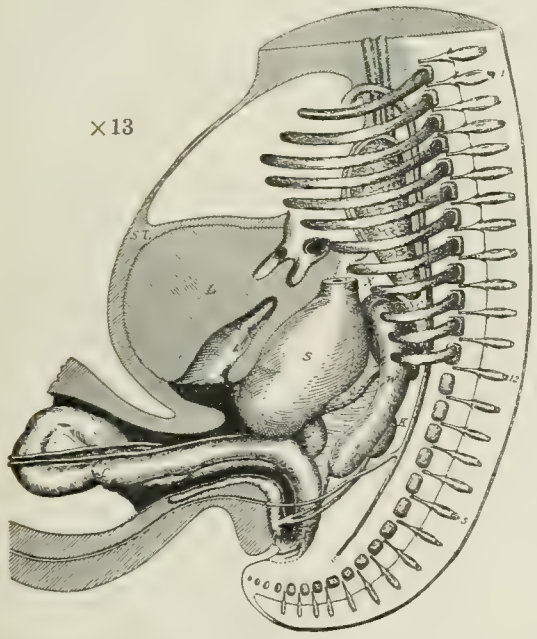



FIG. 1674.—Reconstruction Model of a Human Embryo 17 mm. in length. *C*, cecum; *S*, stomach; *L*, liver. (After Mall.)

duodenum. Posteriorly to the rudimentary liver we have that portion of the alimentary tube which gives rise to the jejunum, the ileum, and the different subdivisions of the large intestine. At first this portion shows only a slight anterior convexity near the vitelline duct, but later it gives rise to the very complex arrangement of the small and large intestines. The most posterior portion of all, the hind-gut, gives rise to the rectum and ends blindly by means of the transitory post-anal gut in the tail of the embryo.

Fig. 1673,A shows the digestive tract of a human embryo 4.2 millimeters long. The wide communication between the mid-gut and yolk sac is shown; also the comparatively straight course of the intestine.

In Fig. 1673,B, taken from an embryo, seven millimeters long, the stomach shows a slight indication of the greater and lesser curvatures, and the general conformation of the stomach can be made out. A loop of the intestine projects ventrally, and the now narrow connection with the yolk sac is shown. The rudiments of the liver and pancreas can be seen arising respectively from the dorsal and ventral sides of the duodenum.

At a somewhat later stage of development (Fig. 1673, C) the form of the stomach is more clearly shown. The duodenum caudad to the pylorus passes backward until it comes close to the dorsal body-wall; it then bends around sharply ventrally and forms a long loop, the convexity of which is directed forward. This loop consists of two nearly parallel arms running near each other. One is directed ventrally and somewhat backward, while the other, which is situated caudad to it, runs dorsally and is again bent near the vertebral column. From this latter bend it passes caudad toward the anus. The convex end of the long loop thus formed extends beyond the body into the umbilical cord, within which there is an excavation for its reception (Fig. 1674). The vitelline duct, which is now undergoing degenerative changes, is connected with the intestine at the ventral end of the long loop just described. A short distance from the vitelline duct, on the caudal end of the loop, a second evagination can be seen. This latter develops into the cecum, and therefore indicates the boundary between the large and the small intestine. "In consequence of these first foldings, four regions of the intestine can be distinguished even now. These are more sharply separated later. The short portion running from the stomach to the backbone and provided with a small mesentery becomes the duodenum (Fig. 1675, *du*); the anterior descending arm (*d*), together with the bend in the loop, furnishes the small intestine. The posterior ascending arm is developed into the colon (*c*), and the terminal part, embracing the last bend, into the sigmoid flexure and rectum (*r*). In embryos

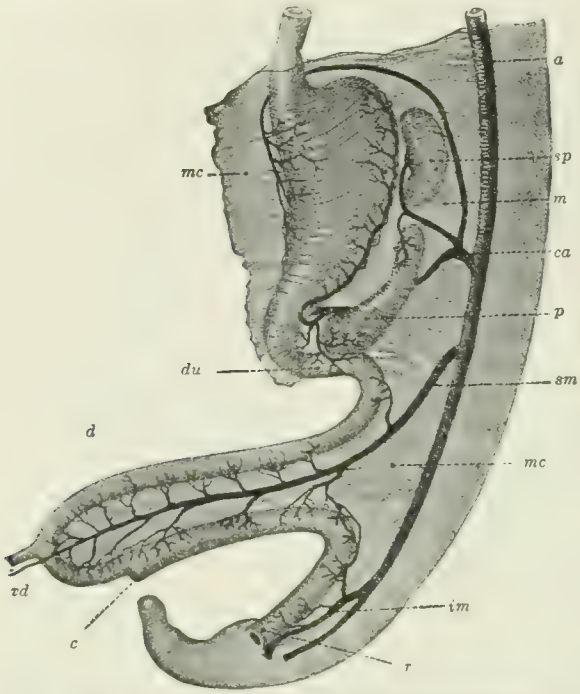



FIG. 1675.—Alimentary Canal of a Six-Weeks Human Embryo. (From Kollmann, after Toldt.) *a*, Aorta; *c*, cecum, on the ascending arm of the intestinal loop; *ca*, arteria celiaca; *d*, descending arm of the intestinal loop which becomes the small intestine; *du*, duodenum; *im*, arteria mesenterica inferior; *m*, mesogastrium; *mc*, mesogastrium commune; *p*, pancreas; *r*, rectum; *sm*, arteria mesenterica superior; *sp*, spleen; *vd*, vitelline duct.

of the third and following months there occur, in connection with a further increase in length, important changes in the position of the stomach and the intestinal loops. The stomach undergoes a double twisting about two different axes, and thereby early acquires a form and position (Fig. 1676) which correspond approximately to the permanent condition. First, its longitudinal axis, which unites cardia and pylorus and is, in the beginning, parallel with the vertebral column, takes an oblique and finally an almost transverse position in consequence of a rotation around the dorsal ventral axis. By reason of this rotation the cardia moves to the left half of the body and downward, but the pylorus more to the right side and somewhat higher. Then at the same time the stomach experiences a torsion around its longitudinal axis by which the original left side becomes the front and the right the back. Consequently the greater curvature comes to lie below, the lesser above. The terminal part of the esophagus is also affected by the torsion. It undergoes a spiral twisting by which this left side becomes the front. . . .

"The intestinal loop with its mesentery passes through a no less fundamental twisting around its place of attachment in the lumbar region than the stomach does. The descending and the ascending arms at first lie side by side, then the latter (which becomes the colon) lays itself obliquely over the former and across the beginning of the small intestine transversely (Fig. 1676, A, *k*).

"Both parts, but especially the small intestine, continue from the end of the second month to increase rapidly in length and to take on a folded condition. Meanwhile the initial part of the colon, called the cecum, which exhibits even in the third month a curved sickle-shaped vermiform appendage, comes to lie wholly on the right side of the body up under the liver (Fig. 1676, A, *bld*). From here it runs in a transverse direction across the duodenum under the stomach to the region of the spleen; then it bends sharply about and descends to the left pelvic region, where it is continued into the sigmoid flexure and rectum. Therefore there are distinguishable in the colon, even in the third month, the cecum, the transverse and the descending colon. An ascending colon is still wanting. It is formed in the succeeding months by the gradual sinking down of the cecum (Fig. 1676, B, *bld*) which was at first under the liver, until in the seventh month it is below the right kidney, and from the eighth month onward descends past the crest of the ilium.

"Meanwhile the cecum has increased in length, and toward the end of gestation is a rather large appendage at the place of transition from the small to the large intestine. It early exposes the want of uniformity in development. The terminal part, which often embraces more than half its length, does not keep pace in its growth with the more rapidly enlarging proximal portion. The former is designated as the appendix vermiformis; the latter as the cecum. At the time of birth the vermiform appendage is still not so sharply differentiated from the cecum as it is a few years later, when it has been converted into an appendage the size of a goose quill and 6–8 centimeters long.

"Within the region embraced by the bends of the large intestine the small intestine, which is derived from the descending arm of the loop, is disposed in more and more numerous folds, owing to its extensive growth in length" (Hertwig).

The permanent mouth is developed as a pit (stomodeum) on the under surface of the rudimentary head (Fig. 1671). This pit extends until it meets the blind end of the fore-gut, being separated from it at first by a thin sheet of tissue composed of outer and inner germ layers, and known as the pharyngeal membrane. By the rupture of this membrane, communication is established with the exterior. The formation of the anus is much more complicated than that of the mouth, and is not fully understood as yet. It arises on the ventral side of the body, in

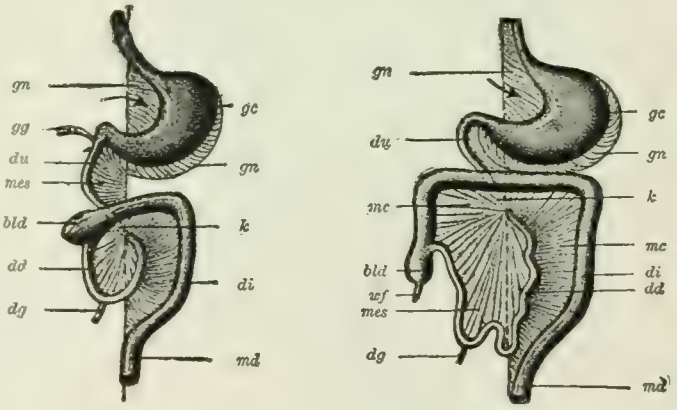



FIG. 1676.—Diagrams of the Development of the Human Alimentary Canal and Its Mesentery. *A*, Earlier, *B*, later stage. (After Hertwig.) *gn*, Greater omentum, which is developed from the mesogastrium. The arrow indicates the entrance to the omentum (bursa omentalis); *gc*, greater curvature of the stomach; *gg*, ductus choledochus; *du*, duodenum; *mes*, mesenterium; *mc*, mesocolon; *dd*, small intestine; *di*, large intestine (colon); *md*, rectum; *dg*, vitelline duct; *bld*, cecum; *wf*, appendix vermiformis; *k*, place where the loops of the intestines cross each other. The colon with its mesocolon crosses the duodenum.

front of the neurenteric canal. There is here, as with the mouth, a thinning of the tissue over a limited area, and thus an anal membrane is formed.

The place where this thinning of the tissue takes place gives rise externally to a pit (proctodeum), which later becomes connected with the hind-gut by

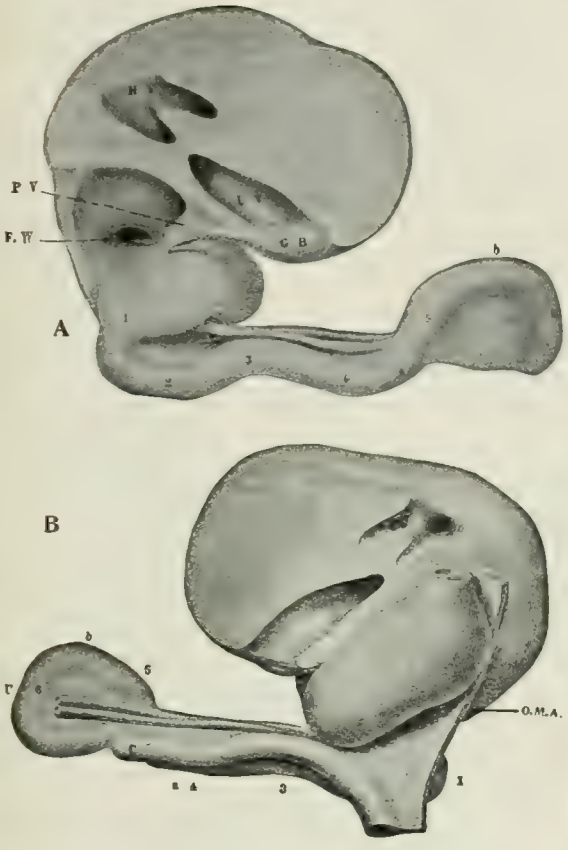



Fig. 1677.—Reconstruction of the Liver and Intestine of a Human Embryo of about Five Weeks. *A*, From the right side; *B*, from the left side. (After Mall.) ×15. *C*, Cecum; *F.W.*, foramen of Winslow; *G.B.*, gall bladder; *H.V.*, hepatic veins; *O.M.A.*, omphalomesenteric artery; *P.V.*, portal vein; *U*, place where the omphalomesenteric artery and vein cross the intestinal loop; *U.V.*, umbilical vein. The numbers 1–6 indicate the commencing intestinal coils. The letters *a* and *b* designate constant points which serve as landmarks in comparing the following series of figures.

the rupture of the above-described anal membrane. The process is therefore similar to that by which the mouth is established.

Until within a few years the growth and arrangement of the coils of the small intestine were but little understood. The first attempt to find a typical arrangement of the coils was made by Henke, followed by Sernoff, Weinberg, and Mall. In the ensuing description I shall follow the investigations of Mall.

As the intestine grows it pushes itself out of the body cavity into the umbilical cord (Fig. 1674). This extra-embryonic position of the intestine had already been noticed by Meckel in 1817. The single loop of which the intestine is composed at this time is shown in the two illustrations forming Fig. 1677, which are from a reconstruction of an embryo of about five weeks. It will be noticed that in Mall's figure the relations of the two arms, which make up the intestinal loop, to each other differ from that of Toldt, which is usually given in the text-books. In the figure of Toldt (Fig. 1675), there is a ventral and dorsal arm to the loop, while Mall gives a right and a left arm. The mesentery between the two lies at right angles to the axis of the embryo in Mall's figures, while in Toldt's it is parallel. His has also described, in his "Anatomie menschlicher Embryonen," similar relations of the intestines. Another point to which Mall calls special attention is that the large intestine lies in the sagittal plane of the embryo, and retains this position until the return of the intestine into the peritoneal cavity.

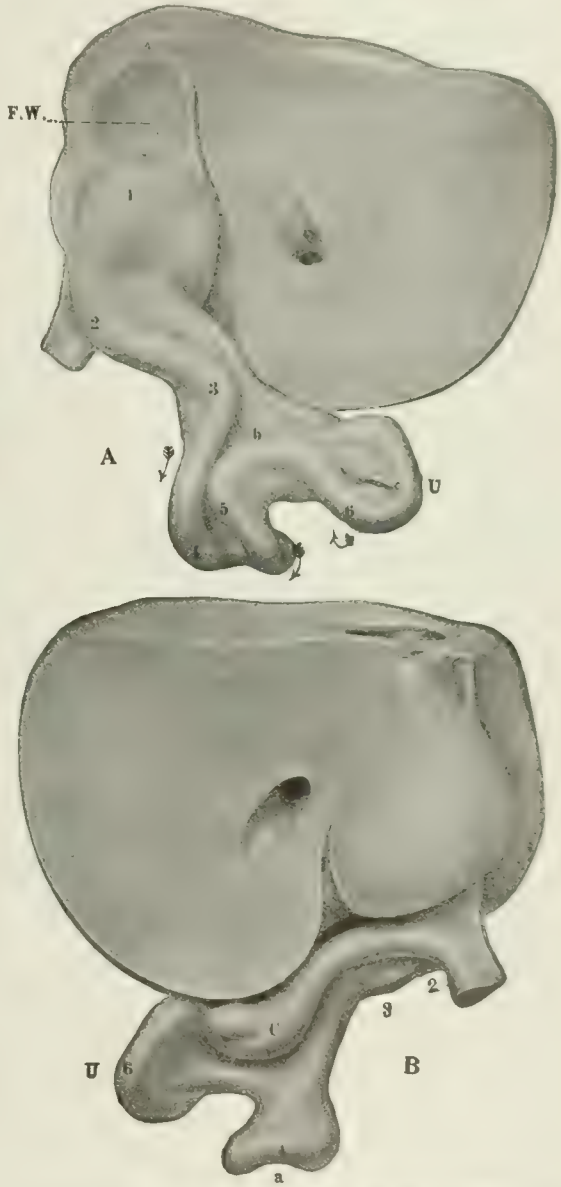



Fig. 1678.—Reconstruction of the Liver and Intestine of a Human Embryo, 24 mm. Vertex-breech Measurement. (After Mall.) ×10 diameters. *A*, From the right side; *B*, from the left side. Letters and numbers as in Fig. 1677.

The right arm of the loop (Fig. 1677, *A*) has a number of short bends, which have an important relation to the future convolutions of the intestine. The omphalomesenteric vessels which lie in the mesentery of the loop in the mid-line serve as a landmark for comparison with older embryos.

The vascular supply of the loop corresponds to

that of the adult, since the omphalomesenteric artery supplies in the embryo the same portion of the intestine that the superior mesenteric supplies in the adult. The same is true of the large intestine. That part which lies at right angles to the long axis of the body is supplied by the superior mesenteric,

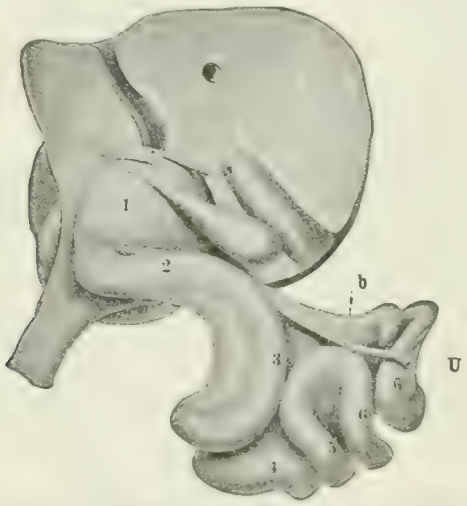



Fig. 1679.—Reconstruction of the Liver and Intestine of a Human Embryo of the Same Size as Fig. 1678, but Somewhat Older. (After Mall.) ×10 diameters. Viewed from the right side. The growth of each individual coil is easily followed.

and that which lies parallel to the long axis by the inferior mesenteric.

In a somewhat older embryo (Fig. 1678), the coils of Fig. 1677 are more sharply defined, and in general it may be said that the coils nearest the cecum are the strongest developed. The length of the loops has about doubled, while the diameter has increased about one-third. The large size of the liver deserves special notice. I shall refer to this point again.

The next embryo that Mall figures (Fig. 1679) is only a little larger than the one shown in figure 1678. The large intestine occupies the same position; it has increased in length, but not in diameter. A well-defined processus vermiformis is pres-

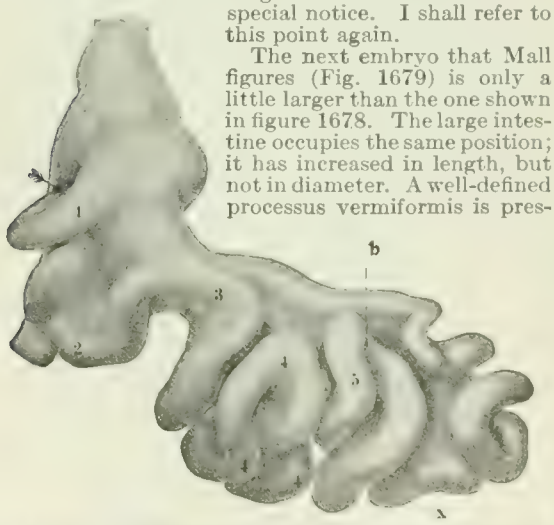



Fig. 1680.—Reconstruction of the Stomach and Intestines of a Human Embryo, 28 mm. Vertex-breech Measurement. Viewed from the right side. (After Mall.) ×13 diameters.

ent on the cecum. A comparison of Figs. 1679 and 1680 will show the growth of the coils of the intestine. While this growth is rapid, the relations of the coils to one another remain practically the same, and can be followed through successive embryos.

For example, the point *b*, which marks the end of loop 5, occupies in all four embryos (Figs. 1677 to 1680) the same relation to the cecum and umbilical vessels. This point seems to be a landmark for determining the loops on the right side of the mesentery, just as *a*, in corresponding views of the left side, is for the intestinal loops on that side of the mesentery (Figs. 1678 and 1680).

The occasion of the intestine being forced out into the umbilical cord has been previously determined by Mall to be the "great amount of shifting which takes place from the head toward the tail on the ventral side of the embryo during its development." The liver also grows very rapidly and occupies nearly the entire abdominal cavity, thus forcing the intestine into the cœlom of the umbilical cord (Fig. 1681). Dexter, in his study of the development of the alimentary tract in the cat, adopted the same explanation for the shifting of the intestines from the peritoneal cavity into the celom of the umbilical cord.

While the forces which compel the intestine to leave the peritoneal cavity and pass into the celom of the cord are well established, it is quite difficult to

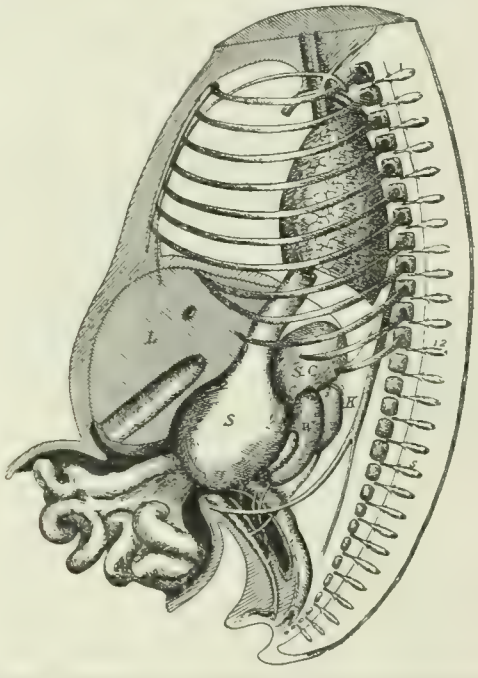



Fig. 1681.—Reconstruction Model of a Human Embryo 24 mm. in Length. *C*, Cecum; *S*, stomach; *L*, liver. (After Mall.)

understand why, at a later period, they return into the abdominal cavity. At the time when they leave the abdomen for the cord, the communication between the body cavity and the celom of the cord is wide, but at the time of their return into the abdomen it is narrow and offers a seeming impediment to their return.

The return into the body cavity of the intestine is quite rapid, and takes place when the embryo is about forty millimeters long. Up to this time, the lower part of the body has not grown as fast as the upper, but now, owing to its rapid growth, the peritoneal cavity becomes much larger and the intestines are drawn back to fill this place.

Mall found full confirmation of the process as outlined in the preceding paragraph in an embryo of thirty-two millimeters in which the actual return of the intestines into the peritoneal cavity was taking place. "Once back in the peritoneal cavity the loops, which collectively lay in the sagittal plane of the cord, are arranged at right angles to the long axis of the body."

While these changes have been taking place in the small intestine, the large intestine from the left flexure of the colon to the rectum has remained quite straight in its course. From the cecum to this flexure, however, the large intestine has gradually extended itself in a curved direction diagonally across the body cavity from left to right, until the cecum comes to lie in the right iliac fossa.

With the return of the small intestine into the peritoneal cavity its upper portion shifts to the left hypochondriac region and the lower part with the cecum shifts to the right hypochondriac region. "With this movement the different portions of the large intestine are marked off; the large intestine being dragged to the left side has its mesentery elongated, at the same time making the S-flexure of the colon." It is during this change of position that the appendix reaches its full stage of development.

Topographical Anatomy.—*Intestinum Tenue* (small intestine).—We have now followed the growth of the intestine, and it remains to describe the position which the coils occupy in the adult. As can be easily inferred, the embryonic condition foreshadows that of the adult.

Mall studied the arrangement of the intestinal coils in the abdomen of forty-one adults. In twenty-one cases the coils were arranged in the same manner. This may be taken as the normal arrangement of the intestine, and the other cases as variations.

In these "normal" cases, the jejunum forms two groups of coils, which occupy the left hypochondriac region. Each of these groups describes more than a complete circle, and both are in contact with the anterior wall of the abdomen (Figs. 1682 and 1683). The intestine then crosses through the umbilical region to the right side of the body. It then makes a turn and again crosses the median line caudad to the first arm, and forms a loop in the left iliac fossa. From here it passes into the pelvis and the lower portion of the abdomen, between the psoas muscles. Fig. 1683 gives the details of the loops as above described.

*Variations.*—The remaining twenty cases examined can be divided into five groups. The first group consists of six cases in which loop 4 (Fig. 1684) extended to the left side of the body. The remainder of the small intestine occupied the position given above.

The second group also consisted of six cases. In these cases the loop 4 was also on the left side, and in addition the loops 1 and 2 were pushed to the right side of the abdomen; that is, all the upper portion of the jejunum formed coils which were situated on the right side of the abdomen.

In the third group there were five cases. The variation here was occasioned by a supernumerary coil from that portion of the small intestine which is situated in the hypogastric region, extending up into the umbilical and right lumbar regions. Sernoff has also described similar cases.

The fourth group consisted of two cases in which coil 4 was again carried to the left side, and the space which it should occupy was filled by two coils, one of which came from the upper part of the jejunum, while the other came from the lower portion of the ileum.

The fifth and last variation was found but once. Loop 4 was elongated, and its place was occupied by a large loop which came up from that part of the ileum which is situated in the hypogastric region. A similar case has been described by Henke.

It is interesting to note that in four of these five groups, loop 4 takes some part in the variation.

*Intestinum Crassum* (large intestine).—The intestinum crassum is divided into the intestinum cecum, processus vermiformis, colon ascendens, colon transversum, colon descendens and colon sigmoideum. The various divisions of the colon form a horseshoe-shaped border about the intestinum tenue (Fig. 1683).

Fig. 1682.—This Figure Shows the Position of the Intestine as Found by Mall in 21 of the 41 Bodies Examined by Him. The abdomen was opened by a ventral incision; the great omentum is turned back and to the left. No portion of the large intestine is exposed to view. The figures 2–6 designate the parts of the intestine which are homologous with the coils seen in the preceding figures. The coil 2 is the continuation of the duodenum. (After Mall.)

*Intestinum Cecum.*—The intestinum cecum is situated in the right iliac fossa and is about sixty millimeters in length and seventy-five millimeters in breadth. It includes that part of the large intestine which lies below the entrance of the small intestine, and also its prolongation, the appendix.

The cecum lies in front of the iliopsoas muscle, and its relations to the walls of the abdomen and the other divisions of the alimentary tract vary, accord-

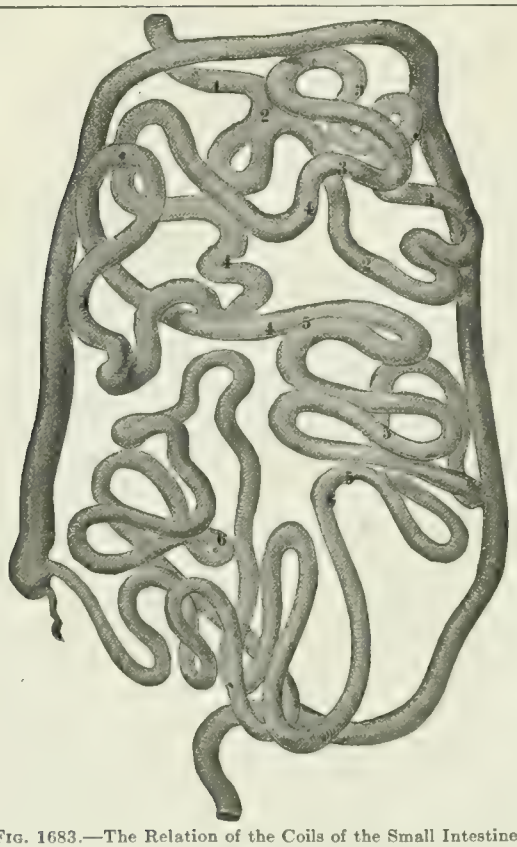


Fig. 1683.—The Relation of the Coils of the Small Intestine to One Another and to the Large Intestine. The figures designate, as in the preceding figure, homologous portions of the intestine. The course which this intestine takes is that of the normal type. (After Mall.)

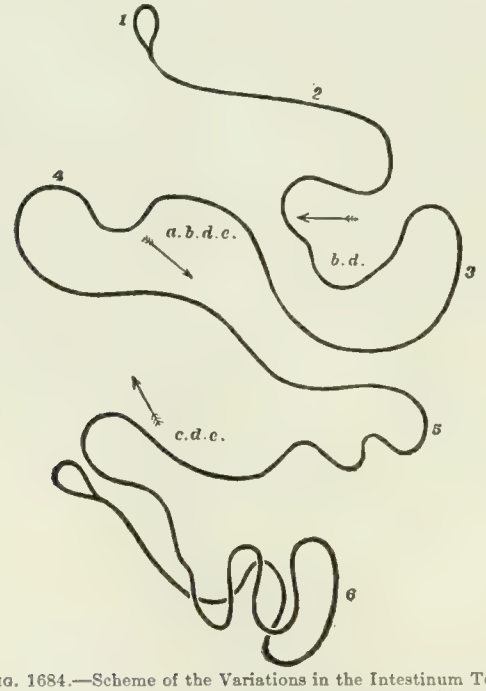



Fig. 1684.—Scheme of the Variations in the Intestinum Tenue. The arrow indicates the direction of the variation. The variations *a* and *bb* are the most frequent; the variation *e* is the least frequent. The numbers correspond to the loops of the intestine described under "development."

ing as they are distended or collapsed. When the cecum is somewhat distended and the small intestine nearly empty, it comes into direct contact with the anterior abdominal wall and comes at once into view, together with a portion of the ascending colon, when the abdomen is opened by means of a crucial incision and the flaps drawn back. In this case it lies above the outer half of Poupart's ligament (Figs. 1685, 1686). On the other hand, when the small intestines are distended or when they have been pushed to the right by a distended sigmoid colon, the cecum is covered by the coils of the small intestine, which are interposed between it and the abdominal wall in front.

*Processus Vermiformis.*—The appendix arises from the inner and back part of the cecum. It varies in size, the extremes being one or two millimeters as the

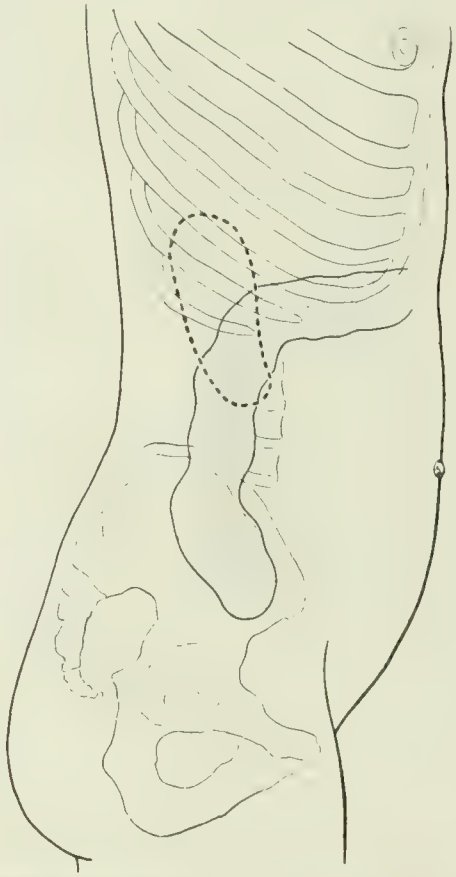


Fig. 1685.—Reconstruction Drawing showing the Position of the Cecum, the Colon Ascendens and Flexura Coli Dextra. The right kidney is shown in outline. (After Merkel.)

shortest and twenty-three millimeters as the longest. Its average length is 9.2 millimeters and its diameter six millimeters. The place where the appendix unites with the cecum can be found by following any two of the three longitudinal bands of muscle which characterize the large intestine, into the right iliac fossa.

The course which the appendix takes varies greatly. It may be drawn out straight. It may be wound into a spiral. Its position also varies, but it will generally be found passing from behind the cecum, either upward and to the left behind the ileum and mesentery, in the direction of the spleen, or downward and to the left so as to lie on the brim of the pelvis, or even project into that cavity. Sometimes it is situated entirely behind the cecum. The appendix is

usually hollow throughout its entire extent. The opening into the cecum is often described as being guarded by a valve. Berry has, however, shown that this valve is inconstant and without any importance.

*Colon Ascendens.*—The ascending colon extends from the cecum below to the flexura coli dextra above (Fig. 1685). It passes at first obliquely backward to the dorsal wall of the abdomen. It then takes nearly a vertical direction, and in its upper portion bends forward toward the abdominal wall. Its posterior circumference borders, on the median side, upon the psoas muscle. After it has left the right iliac fossa, it lies first upon the quadratus lumborum and then on the lower portion of the right kidney. Laterally, it touches the abdominal wall; above, it is completely covered by the coils of the small intestine. When it is highly distended, it may push the small intestine so far to the left that a small portion is visible on opening the abdomen.

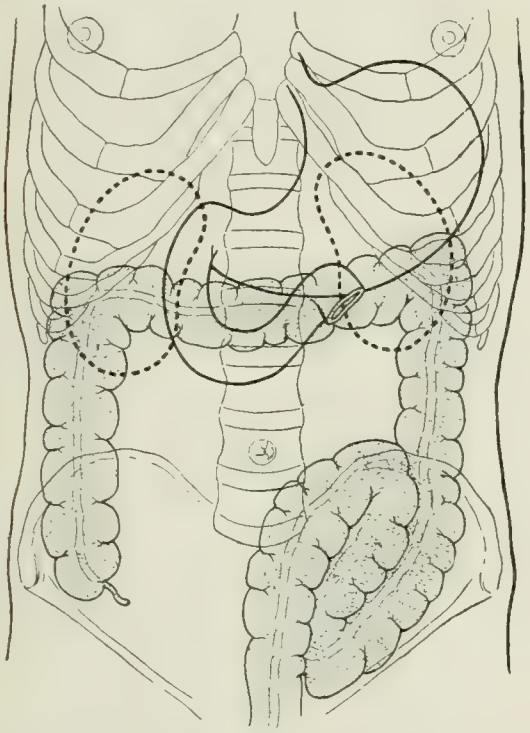


Fig. 1686.—Reconstruction Drawing showing the Position of the Various Divisions of the Colon. Note especially the position of the colon sigmoideum. The stomach, the first portion of the duodenum, and the kidneys are indicated in outline. (After Merkel.)

*Colon Transversum.*—The angle which the ascending colon makes with the transverse colon is quite distinct. In the flexure (flexura coli dextra) the large intestine does not pass directly across the abdomen, but bends somewhat toward the anterior wall of the abdomen, on account of the adjoining organs. From the kidney the large intestine must pass toward the ventral side of the abdomen, in order that it may get in front of the duodenum and pancreas. In front the flexure is covered by the liver, and below it rests upon the coils of the intestine. In the normal condition, when the abdomen is opened, the transverse colon cannot be seen, being covered by the great omentum (Fig. 1682). If one cuts off the omentum or turns it up, the transverse colon is brought into view. In the latter case it appears to run directly from the right to the left. This is, however, a false appearance, due to the fact that the colon is drawn upward out of its normal position. In its normal condition the transverse colon runs in a slight bend, with its convexity below and in front (Fig. 1686).

The left end of this convexity lies on a higher plane than its right, because the right flexure of the colon is prevented by the liver from rising as high as the left flexure. In front of the transverse colon lies the great omentum, and, since this is a thin membrane, we can say that the transverse colon is in contact with the ventral wall of the abdomen. The left portion of the transverse colon borders upon the great curvature of the stomach in such a manner that the lower convex bend of the intestine nearly corresponds to the line of curvature of the stomach. This close relation between the stomach and the transverse colon makes it often difficult to determine their respective boundaries by percussion.

The flexura coli sinistra forms a continuation of the transverse colon. It lies behind the fundus of the stomach, in front of the left kidney, and extends as far as the basal surface of the spleen. The angle which the transverse colon and the descending colon form with each other in this flexure is much more acute than that which is present in the right flexure. Not infrequently the adjoining portions of the two arms of the flexure lie close beside each other. The relation of the transverse colon to the adjoining viscera, and of the arms of the flexure to each other, may be considerably changed by a distended or collapsed condition of the intestines.

*Colon Descendens.*—The descending colon bears much the same relation to the body wall as does the ascending colon (Fig. 1686). Above, it rests upon the convex border of the left kidney, and then passes slightly toward the median line. It extends below to the left iliac fossa, where it joins the sigmoid colon. It is overlaid by the small intestine, and in its normal condition is not exposed to view when the abdomen is opened.

*Colon Sigmoideum.*—The sigmoid colon occupies a very considerable portion of the iliac fossa (Figs. 1686, 1688). It is connected above with the descending colon, and below it passes over the brim of the pelvis and joins the rectum. The upper portion of the sigmoid colon is usually firmly fixed in the fossa; but the lower part is quite movable, in consequence of which it may at times form a loop, which hangs down into the true pelvis.

Figures 1686 and 1688 illustrate two extreme normal positions of the sigmoid colon. The position shown in Fig. 1688 where the flexure hangs down into the pelvis is frequently described as the true type. Merkel, on the other hand, says this is not correct, since it is not found in the majority of cases. The position shown in Fig. 1686 where the summit of the sigmoid colon rises up into the abdomen is at least as frequent and is, in his opinion, the more frequent of the two positions.

*Intestinum Rectum.*—The intestinum rectum is divided into the rectum and pars analis recti. The rectum is the last division of the large intestine, and is situated entirely within the true pelvis. It extends from the sigmoid colon to the anus. From the brim of the pelvis, where it joins the sigmoid colon, it passes downward, backward, and to the right in order that it may reach the median line. In general it follows from this point the curve of the sacrum and coccyx, and ends in the anal canal. The anterior wall of the rectum is longer and more curved than the posterior. In children the rectum has a straighter course than in adults, and is of a relatively larger size.

The rectum is smallest above, near its junction with the colon sigmoideum, and is of the greatest diameter near the pars analis recti where there is a special enlargement known as the ampulla recti. When empty the rectum measures slightly more than two and one-half centimeters in diameter, but in a state of extreme distention it may be as much as seven and one-half centimeters in width.

*Variations.*—I shall call attention to only a few of the important variations of the intestinum crassum.

In cases where the transverse colon is longer than usual, seventy-five centimeters or more, the space from the right flexure to the left flexure is not sufficient to accommodate it. In these cases a V-shaped loop is often found (Fig. 1687, *b*) with its apex directed downward. This may extend as low as the umbilicus. The same variation may be caused by tight lacing; the stomach and transverse colon being displaced downward. Relaxation of the abdominal walls leading to a ptosis of the abdominal viscera may also cause the same variation. Occasionally there is a loop formed which passes upward (Fig. 1687, *a*) in front of the liver or the left arm of the loop may be situated in front of the stomach; both variations are liable to lead to errors in diagnosis. A third variation in which the descending colon appears double is sometimes found (Fig. 1687, *c*). A similar loop is at times found on the right side.

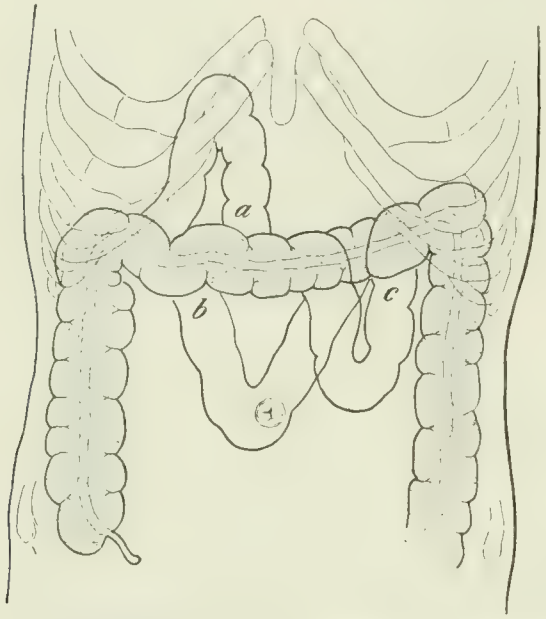



Fig. 1687. Schematic Drawing to Illustrate the Variations in the Position of the Colon Transversum. The normal course of the colon transversum is indicated in stipple; the variations are in outline and lettered *a*, *b*, *c*. (After Merkel.)

Besides the two extreme normal positions, shown in Fig. 1686 and Fig. 1688, the sigmoid colon may present certain variations which are perplexing to the surgeon and may lead to errors in diagnosis. The summit of the loop of the sigmoid colon may extend more or less obliquely to the right and upward (Fig. 1688, *d*, *c*). Sometimes the loop is very long; in this case it passes first across the pelvis and then ascends beside the ascending colon (Fig. 1688, *b*) so that on the right side there are apparently three ascending colons lying side by side. In a few instances it has been found to extend still further and follow the flexura coli dextra and lie parallel to the transverse colon with the rounded extremity of the loop turned to the left (Fig. 1688, *a*). A still more complex condition arises when this last variation occurs in connection with one of the variations of the transverse colon shown in Fig. 1687.

*Meckel's Diverticulum* (diverticulum ilei).—In 2.2 per cent. of 3302 cases, especially examined for its presence, the proximal portion of the ductus entericus, the communication of the primitive intestine of the embryo with the yolk sac, persisted, giving rise to a short, wide protrusion from the lower part of the ileum: Meckel's diverticulum. It is usually about five centi-

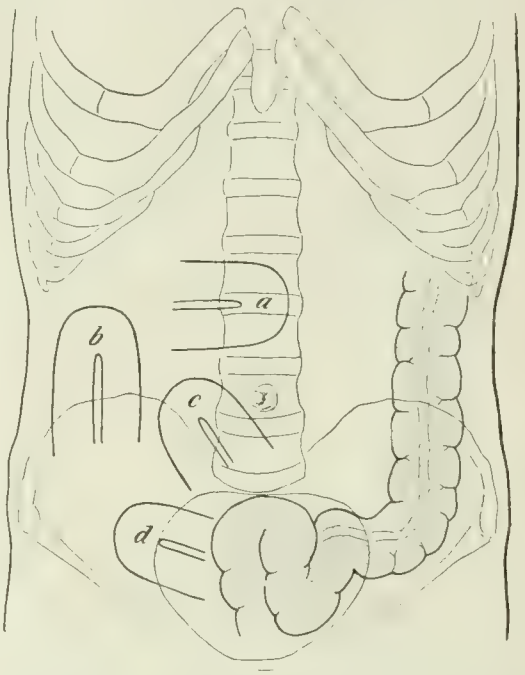



Fig. 1688.—The Position of the Colon Sigmoideum as Indicated in this Illustration is that Frequently Described as the Normal Position. Compare this illustration with Fig. 1686. Variations in the position of the colon sigmoideum are indicated in outline and lettered *a*, *b*, *c*, *d*.

meters long, and of the same width as the portion of the intestine from which it arises. It is most frequently found about 100 centimeters from the valvula coli and is from five centimeters to twelve centimeters in length.

Arterial Supply. *Gross Anatomy.*—The arterial supply of the digestive tract is of interest not only to the anatomist but also to the physiologist, to the clinician, and to the surgeon. Outside of the text-books of systematic anatomy there are but few special descriptions of the arterial supply of the intestinum tenue and the intestinum crassum. The most important contribution of recent years is that of Waldeyer to which I will refer my readers for the older literature.

A study of the gastrointestinal arterial supply that is highly instructive and deserves careful consideration, is that made by Byron Robinson in 1908. Unfortunately it is accompanied by much that is irrelevant, and the illustrations are poorly executed.

The following account of the gross distribution of the arteries to the digestive tract is based upon a paper which appeared during the present year (1913) by Corsy and Aubert.

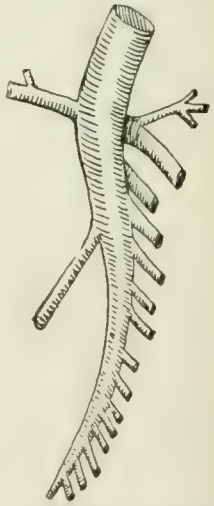


Fig. 1689.—Trunk of the Arteria Mesenterica Superior. On the left side one can recognize seven large branches and the bifurcation of the artery at the inferior extremity. (After Corsy and Aubert.)

Arteria Mesenterica Superior. *Origin.*—The arteria mesenterica superior arises from the anterior

surface of the aorta at the level of the intervertebral disc between the twelfth dorsal and the first lumbar vertebræ.

*Direction.*—In bodies fixed by injecting formalin the arteria mesenterica superior has an irregular S-shape (Fig. 1689). It can be divided into a superior part, relatively short, with a concavity, slightly directed to the left, that embraces the third portion of the duodenum, and an inferior portion concave to the right.

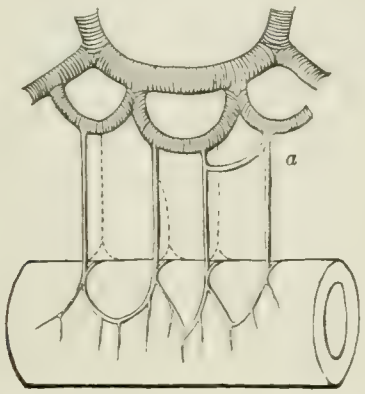



Fig. 1690.—Arcades and Origin of the Arteriæ Rectæ. Note the supplementary arcade at *a*, from which arise two arteriæ rectæ anteriores (type *D*). (After Corsy and Aubert.)

The general direction of the artery appears oblique from top to bottom and from left to right, crossing the mid-line.

*Termination.*—The arteria mesenterica superior terminates, according to most authors, at the ileocecal angle by anastomosing with the iliac branch of the ileocecal artery; a few authors make the artery of the ileocecal angle the terminal branch. Lardennois and Okinczyc, from the standpoint of embryology, make the arteria mesenterica superior end from sixty centimeters to ninety centimeters from the ileocecal angle. This point corresponds to the end of the omphalomesenteric artery where it divides into a right and a left anastomosing branch. In confirmation of the above statement Lardennois and Okinczyc cite a case where the diverticulum ilei (Meckel's diverticulum) with its mesentery and artery persisted. Corsy and Aubert have seen a case where the artery going to the diverticulum was given off from the bifurcation of the arteria mesenterica superior. From a study of this case Corsy and Aubert conclude, with Lardennois and Okinczyc, that the termination of the arteria mesenterica superior corresponds to the loop of intestine whose mesentery is the longest. This is usually found about sixty centimeters from the ileocecal angle.

At this level the arteria mesenterica superior often divides into two branches: a right, smaller, which goes toward the ileocecal angle where it terminates; a left branch, larger, which continues the series of the left branches of the arteria mesenterica superior.

The right terminal branch near its termination at the end of the ileum, sometimes at the level of the bifurcation of the arteria mesenterica superior, gives off a branch which anastomoses with the ileocolic artery. Three types can be recognized: (1) The anastomosing branch takes no part in the arterial supply of the intestinal loop; (2) it partially supplies the loop; (3) it furnishes the entire supply.

*Branches.*—It is customary to divide the branches arising from the arteria mesenterica superior into a right and a left group. Corsy and Aubert divide them into branches which pass to the intestinum crassum and branches which pass to the intestinum tenue. These latter arise in such a manner that they form a half spiral about the main trunk of the arteria mesenterica superior.

*Branches to the Intestinum Tenue.*—According to Dwight these are twenty in number. Corsy and Aubert find them less numerous and subdivide them into two groups: a superior group composed of six or seven large-sized arteries and an inferior group composed of a variable number of smaller arteries (Fig. 1699). From a number of personal observations it appears to me that the number of these latter arteries is correlated with the length of the intestinum tenue.

After a longer or shorter course in the mesentery each of these arteries bifurcates into a right and a left branch of equal caliber. These two branches form anastomoses with the adjoining arteries and form in this manner the first of a series of arcades. From this series of arcades, branches are given off, sometimes at a right angle, sometimes obliquely, which divide dichotomously and anastomose with each other thus forming a second series of arcades. In like manner a third series of arcades is formed. Corsy and Aubert find usually three series of arcades, rarely four; sometimes, at the level of the intestinal loop where the mesentery is the longest, there may be a series of five arcades. In each series of arcades the caliber of the arteries is less than in the preceding series.

*Arteriæ Rectæ.*—The last series of arcades form what are termed by Dwight "parallel vessels" because they run parallel to the attached border of the intestine. From these parallel vessels the arteriæ rectæ arise which, according to their final distribution on the intestine, can be distinguished as anterior and posterior arteriæ rectæ (Fig. 1690). As the mesentery approaches the intestine the two layers of which it is composed separate and pass one on either side of the intestine, leaving a narrow strip of the intestinal wall free from a mesenteric investment. It is in these layers that the anterior and posterior arteriæ rectæ are embedded.

Each artery divides into a long or encircling branch and a short or median branch. If the mesentery be removed, by cutting it close to the wall of the intestine, we can recognize four parallel lines of arterioles which have been divided; the two outer lines correspond to the long or encircling branches, the two middle lines correspond to the short or median arteries.

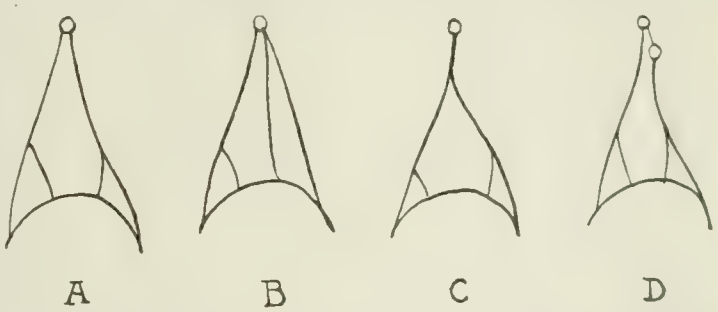



Fig. 1691.—Scheme of the Arteriæ Rectæ. Above cross-section of the parallel artery; below the four terminal branches. In *A* the anterior arteria recta and the posterior arteria recta give off a median artery. In *B* the anterior median artery arises from the parallel artery. In *C* there is a short trunk formed by the fusion of the proximal portions of the anterior and posterior arteriæ rectæ. In *D* the anterior arteria recta arises from a supplementary arcade. (See also Fig. 1690.) (After Corsy and Aubert.)

Corsy and Aubert give four schemes illustrating the distribution of the arteriæ rectæ. In Fig. 1691, *A*, the anterior and posterior arteries give off a median branch; in *B*, the posterior median artery arises from

the parallel vessel; in *C*, the two arteriæ rectæ fuse for a short distance and then divide as in *A*; in *D*, the posterior artery arises from a supplementary arcade (see also Fig. 1690).

The gross distribution of the arteries in the wall of the intestine has been worked out very carefully by Mall in his study of the vascular supply of the dog's intestine. I have found by numerous comparisons that his description applies to the human intestine. I shall, therefore, use his illustrations in connection with the following description.

Fig. 1692 shows a portion of the intestine, with the arteries injected, cut open along the attached border and spread out flat. The long or encircling arteries

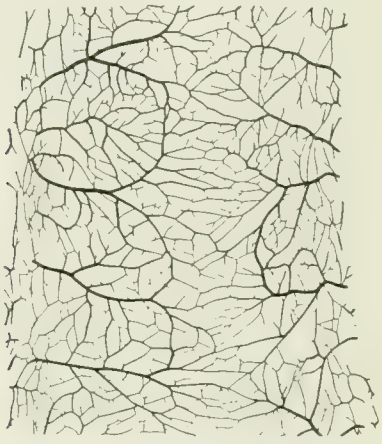


Fig. 1692.—Arterial Injection of the Wall of the Intestinum Tenue of the Dog. The intestine was cut open along the attached border and spread out flat. Note the long, or encircling arteries, their anastomosis along the free border, and the series of interveining arcades. One-third natural size. (After Mall.)

can be seen forming a series of arcades on each side of the intestine; from these arcades branches are given off which anastomose freely with each other and with the arteries of the opposite side. The divided arteries are arranged along the incised margins of the intestine.

In Fig. 1693 the arrangement of the arteries is shown when the intestine is cut open along the free border and spread out flat. The divided trunks of the long or encircling arteries are arranged in two parallel rows situated some distance from the incised border of the intestine; between these rows there can be seen, less distinct, the two rows of the divided trunks of the smaller short or median arteries. The free anastomoses of the branches of both sets of arteries can be plainly seen.

The ultimate distribution of the arteries within the wall of the intestine will be described in connection with the histology of the intestine.

*Branches to the Intestinum Crassum.*—Thus far we have considered the arteries distributed to the intestinum tenue or the group arising from the left side of the arteria mesenterica superior. For the arteries distributed to the intestinum crassum, or the group arising from the right side of the arteria mesenterica superior, Corsy and Aubert propose to simplify the nomenclature by using, in the place of the present terms, names which designate the distribution of the two arteries.

In his study of the arteries supplying the colon Waldeyer states that the numerous descriptions of the branches derived from the arteria mesenterica superior can be classified under two types. In the first there are three branches passing from the arteria mesenterica superior to the colon; in the second there are also three, but the branch called the inferior colic is in reality the terminal branch of the arteria mesenterica superior leaving, therefore, two main branches arising from the arteria mesenterica superior. Waldeyer, himself, describes only two branches as being given off from the arteria mesenterica superior to the colon.

Corsy and Aubert, in their study of the arteria mesenterica superior, found in 120 adults fifty-nine per cent. with two branches and forty-one per cent. with three branches. In thirty infants, fifty-three per cent. had two branches and forty-seven per cent. had three branches. They consider two branches as the normal number.

The inferior artery (Fig. 1694) they call the artery of the ileocecal angle (artère de l'angle ileocécal); the superior artery (Fig. 1694) they call the artery of the right angle or of the hepatic angle (artère de l'angle droit ou hépatique). The arteria colica dextra they find in only forty-one per cent. of the cases studied and prefer to call it, when it is present, the artery of the ascending colon (artère du colon ascendant). In like manner they name the artery passing to the colon transversum, the artery of the transverse colon (artère du colon transverse). This latter artery may be a branch of the arteria mesenterica superior, but most frequently it arises from the artery of the hepatic angle.

*Artery of the Hepatic Angle.*—This artery (Fig. 1694) arises from the arteria mesenterica superior from five millimeters to fifteen millimeters below the margo anterior of the pancreas. From this point the artery describes, with the concavity directed cepha-

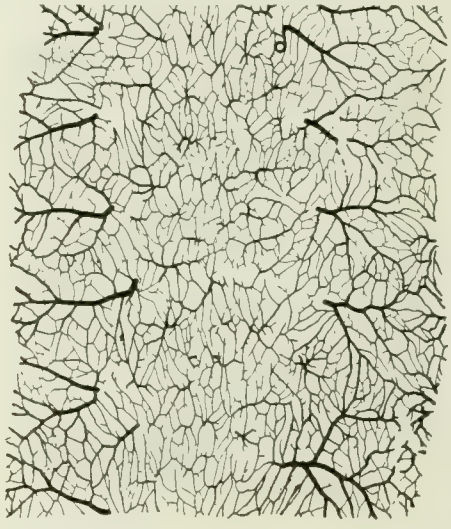


Fig. 1693.—Arterial Injection of the Wall of the Intestinum Tenue of the Dog. The intestine was cut open along the free border and spread out flat. Note the short, or median arteries, occupying the middle portion of the illustration. The long or encircling arteries can be seen arranged on either side of the median arteries with which they freely anastomose. One-third natural size. (After Mall.)

lad, a slight curve toward the hepatic angle (flexura coli dextra). When it has reached a distance of five or six millimeters from the flexure it bifurcates into two branches, one of which supplies the colon ascendens, the other supplies the colon transversum. This artery forms an anastomosis on the one hand with the artery of the ileocecal angle, on the other hand with the artery of the splenic angle (artère de l'angle splénique).

We have seen that in the case of the intestinum tenue a series of arcades are formed before the arterial radicles end in the intestinal wall. In like manner there is a series of arcades formed for the intestinum crassum; but, in the case of the intestinum crassum, there are rarely more than two, while in the

case of the intestinum tenue three or more series of arcades is the rule.

*Artery of the Ileocecal Angle.*—This artery (Fig. 1694) arises from four to five centimeters below the preceding artery and is of a slightly larger diameter. It passes obliquely downward and to the right forming with the trunk of the arteria mesenterica superior an angle of about 45°. The general direction of the artery depends upon a high or low situation of the cecum.

After a course of from five to seven centimeters it divides at a distance of four or five centimeters from the attached border of the intestine into four terminal branches: an ascending, or colic branch; a descending or left iliac branch; a posterior appendiculo-cecal branch, and an anterior cecal branch.

Corsy and Aubert consider the arteria colica dextra, the branch supplying the ascending colon, as an aberrant branch of one of the two main arteries. They found it more frequent in new-born children than in adults, and appear to consider it as being possible that it is absorbed by one or the other of the main branches.

Arteria Mesenterica Inferior.—*Origin.*—The arteria mesenterica inferior arises, according to Corsy and Aubert, in 108 out of the 120 cases studied, between three and four centimeters above the bifurcation of the aorta and in 85.5 per cent. of cases between the superior border and the inferior border of the third lumbar vertebra.

*Direction.*—The arteria mesenterica inferior arises from the anterior surface of the aorta a little to the left of the median line. It passes downward along the anterior surface of the aorta for about two centimeters. After a course of from thirty-five to forty-five millimeters it reaches the level of a horizontal plane passing through the bifurcation of the aorta, from which it is separated about fifteen millimeters. From this point the artery changes its direction and describes a curve, with its concavity directed toward the median line. About four centimeters above the promontorium it attains the mid-line; after crossing the promontorium, at the level of its external third, the artery continues in the mesocolon sigmoideum to the rectum where it terminates in one or two hemorrhoidal branches.

*Branches.*—It is more difficult to reduce the various descriptions of the branches of the arteria mesenterica inferior to a type than in the case of the arteria mesenterica superior. Corsy and Aubert, after analyzing all the descriptions of the artery find that they can be reduced to two types: (1) After a course of two or three centimeters the arteria mesenterica inferior gives off a branch which is distributed to the splenic angle (flexura coli sinistra), the artery of the splenic angle (artère l'angle splénique), about fifteen millimeters below it gives off a second branch which is distributed to the iliac angle (artère de l'angle iliaque ou sigmoïde). This type was found in sixty-three cases out of the 120 studied; approximately 52.5 per cent. (Figs. 1694 and 1695). (2) After a course of between three or four centimeters the arteria mesenterica inferior gives off two branches which arise from a very short trunk, one might say there was a bifurcation of the arteria mesenterica inferior (Fig. 1696). This was found in twelve instances, ten per cent. of the 120 cases studied. In other instances the arteria mesenterica inferior gave off a longer branch which divided into the artery of the splenic angle and the artery of the iliac angle. This mode of division, which is only a drawing out of the short trunk in the first instance, was found in forty-five cases or 37.5 per cent. of the 120 cases studied.

The arteria mesenterica inferior in each instance

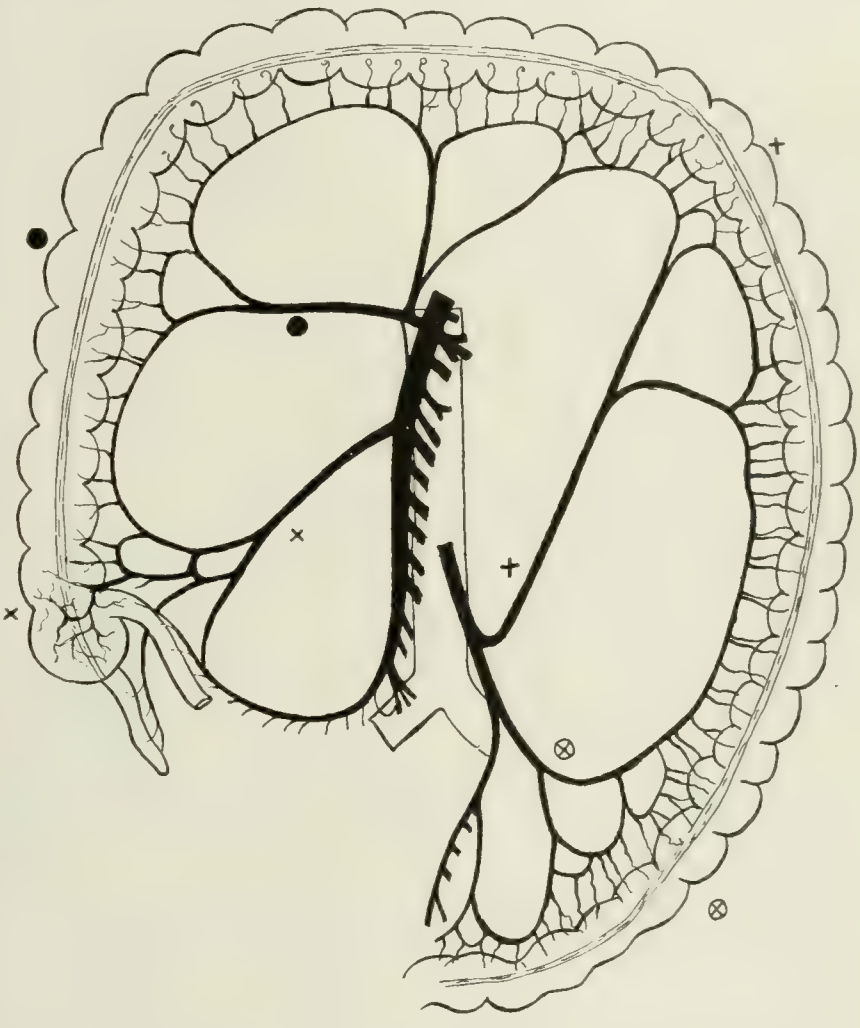


Fig. 1694.—General Scheme of the Arterial Supply of the Intestinum Crassum:
● Artery of the hepatic angle.
× Artery of the ileocecal angle.
⊗ Artery of the iliac angle.
+ Artery of the splenic angle. (After Corsy and Aubert.)

continues its course and terminates in the arteria hæmorrhoidalis superior.

*Artery of the Splenic Angle.*—The artery of the splenic angle (arteria colica sinistra) arises from twenty to twenty-five millimeters below the origin of the arteria mesenterica inferior from the aorta (Fig. 1694). When it arises at a lower level it is generally in connection with the following artery. It is often of a very small caliber, but at times it has a diameter of one to 1.5 millimeters. The artery takes a recurrent course forming with the arteria mesenterica inferior an angle of about 60° to 80°; in a few rare instances its course is horizontal.

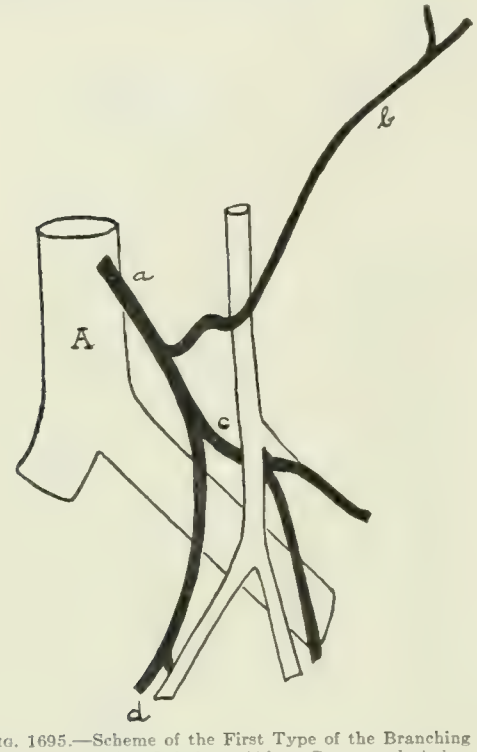



Fig. 1695.—Scheme of the First Type of the Branching of the Arteria Mesenterica Inferior. (After Corsy and Aubert.) *A*, Aorta; *a*, arteria mesenterica inferior; *b*, artery of the splenic angle; *c*, artery of the iliac angle; *d*, arteria hæmorrhoidalis superior. The vessel in outline is the vena mesenterica inferior.

At a variable distance from the splenic angle (flexura coli sinistra) the artery divides into two branches: an ascending, which anastomoses with the left branch of the artery of the hepatic angle and thus forms part of the circle of Riolan; a descending, which anastomoses with the ascending branch of the artery of the iliac angle. In general the artery does not give off any branches; in some cases, however, it gives off a small branch to the right which follows the vena mesenterica superior and anastomoses with the artery to the colon transversum near its origin. To the left it may give off a branch for the colon descendens.

*Artery of the Iliac Angle.*—The artery of the iliac angle (Fig. 1694) arises, as a rule, from the arteria mesenterica inferior at the level of the bifurcation of the aorta about fifteen or twenty millimeters to the left of the median line; equally often (thirty per cent. of the cases) above or below this point.

The artery of the iliac angle is situated above the iliac vessels and follows, eventually, a course nearly parallel to them. It divides into two branches: a superior and an inferior; these in turn divide and form one or two sets of arcades. In rare instances the artery divides into three branches and there are thus formed the three arteriæ sigmoideæ of Jonnesco.

Regional Variations. *Arteries of the Flexura Duodenojejunalis.* This is a zone of transition. The transverse portion of the pars inferior duodeni receives its arterial supply along its superior border; the jejunum receives its supply along its attached border (inferior at the level of the flexura); the zone of transition passes through the pars ascendens duodeni.

If the arteria mesenterica superior be raised up there can be seen (Fig. 1697) passing to the right and entering the substance of the pancreas an artery of considerable size, the pancreatico-duodenale (arteria pancreaticoduodenalis inferior); passing to the left there can be seen a small artery arising—sometimes from the arteria mesenterica superior, sometimes from the arteria pancreaticoduodenalis inferior; this is the arteria duodenojejunalis, which, after a short course, bifurcates into a duodenal branch which anastomoses with the arteria pancreaticoduodenalis inferior and into a jejunal branch which crosses the duodenum tangentially and eventually terminates upon the beginning of the jejunum.

Fig. 1696.—Scheme of the Second Type of the Branching of the Arteria Mesenterica Inferior. (After Corsy and Aubert.) *a*, Aorta; *b*, arteria mesenterica inferior; *c*, artery of the splenic angle; *d*, artery of the iliac angle; *e*, arteria hæmorrhoidalis superior; *f*, artery of the colon transversum (arteria colica media).

The two branches of the duodenojejunalis anastomose between themselves and with the neighboring arteries. The course of these vessels is sinuous and one can see quite distinctly that the intestine has undergone a torsion.

*Arteries of the Jejunum.*—The first eight to ten centimeters of the jejunum have only a single arterial arcade; this is formed by the parallel vessel which is situated, at first, close to the attached border of the intestine but gradually recedes from it (Fig. 1698, A). This parallel vessel forms the termination of the duodenojejunal artery and also of the jejunal artery.

This last is a small artery which arises, as a rule, independently from the arteria mesenterica superior not far from the muscle of Trietz; its course is always preduodenal. When it has reached a position not far from the attached border of the intestine it divides into two branches which in turn bifurcate into a superior and an inferior branch.

*Arteries of the Jejuno-ileal Portion.*—Corsy and Aubert divide the vascularization of the intestinum tenue into two very irregular portions; a superior, or jejuno-ileal, and an inferior portion, or ileocolic. The superior portion commences with a single arcade: this is rapidly followed by two and finally by three arcades. The inferior portion is, according to Corsy and Aubert, the fifteen to twenty centimeters to the right of the bifurcation of the arteria mesenterica superior, a place where the arcades diminish in number until only a single arcade is present. In a few instances the anastomosis which is formed with the artery of the ileocecal angle gives rise to a second arcade (Fig. 1699).

*Arteries of the Ileocolic Portion.*—Three types can be recognized (Fig 1700): (1) The ileal branch of the artery of the ileocecal angle anastomoses with the arteria mesenterica superior, but does not send any branch to the ileum. This type was found by Corsy and Aubert in two per cent. of the cases they studied. (2) The ileal branch of the artery of the ileocecal angle anastomoses with the arteria mesenterica superior some distance from the ileocecal angle and sends a few branches to the ileum. This type was found by Corsy and Aubert in 45 per cent. of the cases they examined. (3) The ileal branch of the artery of the ileocecal angle forms a direct anastomosis with the arteria mesenterica superior and furnishes most of the arterial supply to the ileum. Corsy and Aubert found this type the more usual one: fifty-three per cent.

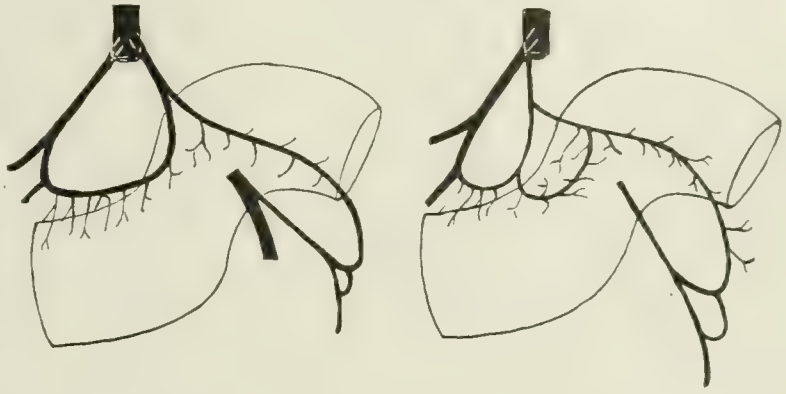



Fig. 1697.—Arteries of the Flexura Duodenojejunalis. The small arteria duodenojejunalis can be seen in A, arising from the side of the arteria mesenterica superior. It divides almost immediately into two branches, a right and a left. The right forms an anastomosis with the arteria pancreaticoduodenalis inferior; the left with the first arteria jejunalis which arises from a trunk common to it and the second arteria jejunalis. In *B*, the arteria duodenojejunalis is a branch of the arteria pancreaticoduodenalis inferior. (After Corsy and Aubert.)

*Arteries of the Intestinum Crassum.*—The general distribution of the arteries to the intestinum crassum has already been described; there remains the detailed account of the supply to the intestinum cecum and processus vermiformis (Fig. 1701).

One can recognize four branches of the artery of the ileocecal angle as being distributed to this portion of the intestine. (1) An ascending colic; this ascends along the colon and forms an anastomosis with the artery of the hepatic angle. (2) An ileal; this forms an anastomosis with the right terminal branch of the arteria mesenterica superior. (3) A ceco-appendicular; this may at times be found as two independent arteries, but as a rule they have a common trunk. The cecal division gives off a few arterioles to the ileum and is eventually distributed to the cecum. The appendicular division usually extends the whole length of the processus vermiformis; it may occasionally send a recurrent branch to the ileum. (4) An anterior cecal; this branch is distributed on the anterior surface of the cecum.

Histological Structure.—*Intestinum Tenue.* The intestinum tenue is composed of four coats. Named from without inward they are: tunica serosa; tunica muscularis; tela submucosa, and tunica mucosa (Fig. 1702).

*Tunica Serosa.*—The tunica serosa is the external or peritoneal covering of the intestine. It covers nearly the entire circumference of the mesenterial small intestine. Along the mesenteric border of the intestine it becomes continuous with the two layers of the mesentery leaving the narrow strip of intestine, between the two layers, free from a peritoneal investment. The duodenum is only to a limited extent covered with a tunica serosa.

Histologically the tunica serosa consists of an outer layer of thin, flat, polygonal mesothelial cells and an inner connective-tissue layer. The visceral serosa is about half the thickness of the parietal serosa.

*Tunica Muscularis.*—The tunica muscularis consists of two layers of smooth muscle; an outer, stratum longitudinale, in which the bands of smooth muscle run parallel to the long axis of the intestine, and an inner, stratum circulare, in which they are arranged circularly. Between the two layers there is a more or less well-developed layer of connective tissue which contains blood-vessels, lymphatics, and a gangliated plexus of nerves. The stratum circulare is the thicker of the two layers.

*Tela Submucosa.*—The tela submucosa consists of areolar connective tissue in which the bundles of white fibers run obliquely to the long axis of the intestine. It is easily separated from the stratum circulare of the tunica muscularis but with difficulty from the lamina muscularis mucosæ. In the duodenum the glandulæ duodenales (Brunner's glands) project into this layer and the same is true of the noduli lymphatici in the jejunum and ileum. The blood-vessels and lymphatics branch freely in this layer and it also contains a gangliated plexus of nerves.

Surgically it is the most important coat of the digestive tract. Its importance was first brought to the attention of surgeons by the experimental work of Halsted and Mall and has been confirmed by later investigations. They showed that sutures of the intestine that included only the tunica serosa or the tunica serosa and the tunica muscularis were insufficient; that sutures that included all the coats of the intestine caused leakage along the suture or led to the formation of pathological growths arising from the injured glandulæ intestinales. On the other hand sutures that just passed through the tela submucosa gave the best results. "Each stitch should include a bit of the submucosa. A thread of this coat is much stronger than a shred of the entire thickness of the serosa and muscularis" (Halsted).

*Tunica Mucosa.*—The tunica mucosa can, for convenience of description, be divided into two parts: the lamina muscularis mucosæ and the mucosa proper.

Between the two there is a layer of reticulated fibers, the fibrous layer of Mall.

The lamina muscularis mucosæ consists of bands of smooth muscle arranged in two layers; an external longitudinal layer and an internal circular layer. The longitudinal layer is the thicker of the two layers, the opposite of the arrangement in the tunica muscularis. The two layers cannot be separated from one another for, at the boundary line between the two, the muscle bundles interweave. Prolongations from this layer extend through the mucosa into the villi and it is stated that by their contraction the villi may be shortened.

As the veins from the mucosa pass through the lamina muscularis mucosæ the smooth muscle cells are arranged about them in the form of a sphincter (Mall). At those places where the larger of the noduli lymphatici are situated the lamina muscularis mucosæ is wanting.

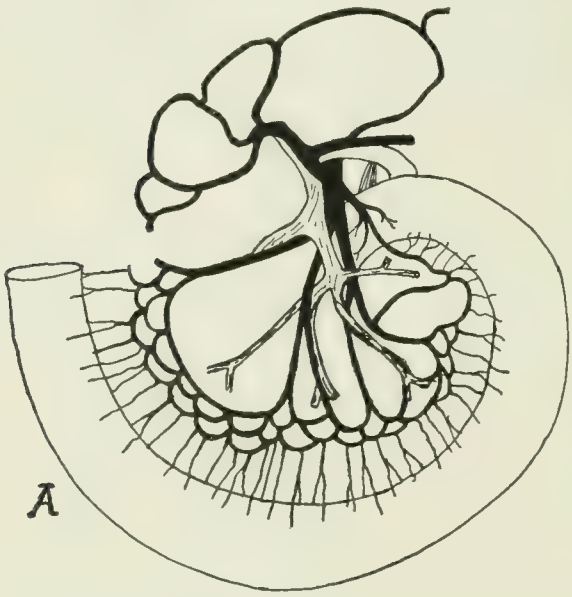
If the intestinum tenue be cut open and spread out under water, with the tunica mucosa uppermost, two things at once attract attention; (1) that the tunica mucosa itself is thrown into folds which cannot be effaced even by forcible extension; these folds are the plicæ circulares (valvulæ conniventes), (2) that the entire surface of the mucosa presents a soft, velvety appearance due to minute, closely set processes—the villi intestinales.

*Plicæ Circulares.*—These consist of a fold of the tunica mucosa, that is, of two layers placed back to back and united by prolongations of the tela submucosa. The tunica muscularis takes no part in the formation of these folds (Fig. 1702).

Kazzander has described three types of plicæ: (1) Those that extend only part way around the intestine; (2) those that completely encircle the intestine; (3) those that have a spiral arrangement. In rare cases this last type may extend two or more times around the intestine.

The plicæ circulares are not uniformly distributed throughout the intestinum tenue. In the extreme upper part of the duodenum they are wanting, but immediately after the entrance of the ductus choledochus they are very large and closely arranged. They become smaller and less frequent in the distal portion of the jejunum and have, as a rule, disappeared at the lower end of the ileum. According to Kazzander, there are 678 plicæ in the male and 644 in the female.

*Villi Intestinales.*—The villi intestinales are structures peculiar to the intestinum tenue although, as we shall see, they are present in a modified form in the intestinum crassum at certain stages of its development. As already stated it is the presence of villi that gives to the intestinum tenue its velvety appearance. They cover the plicæ circulares as well as the intervals between them (Fig. 1702). Hilton has shown that the form of the villi differs according to the character of the food. Broadly stated it can be said that in those animals that exist on a vegetable diet the villi are wide and leaf-like, while in flesh-eating animals they are long and finger-like.



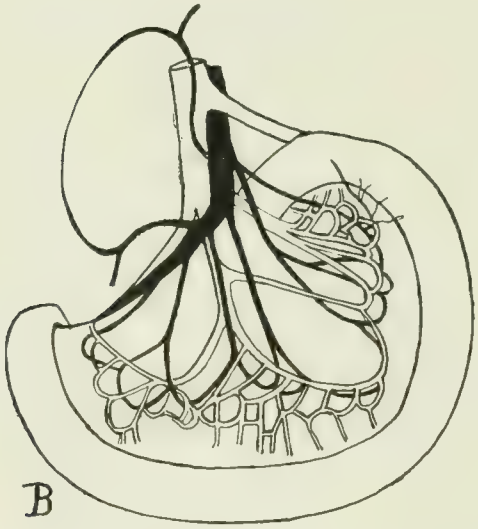




Fig. 1698.—Arteries and Veins of the First Portion of the Intestinum Jejunum. In *A* the arteria duodenojejunalis has a tendency to become the first arteria jejunalis. Note the early appearance of two arcades; also their irregularity. In *B* the veins are especially shown. Note their interlacing with the arteries. (After Corsy and Aubert.)

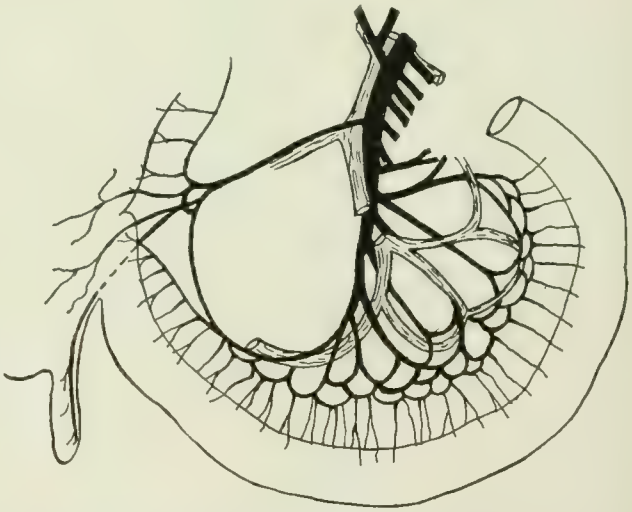


Fig. 1699.—Arteries of the Terminal Portion of the Intestinum Ileum. The bifurcation of the arteria mesenterica superior can be seen at the point where one of the contributary branches of the vena mesenterica superior has been divided. The artery arising from the arteria mesenterica superior just above its bifurcation, and passing to the right, is the artery of the ileocecal angle. (After Corsy and Aubert.)

In omnivora they correspond to either the herbivorous type or to the carnivorous type. Occasionally, as for example in man, we find both types present in the same individual. In the human duodenum they are leaf-like; in the jejunum they become longer and thinner; in the ileum they are finger-like or club shaped.

Villi are found in greatest number in the duodenum and jejunum, gradually becoming smaller and less numerous in the ileum. They vary in length from 0.5 millimeter to 0.75 millimeter. According to Sappy there are about twelve villi to the square millimeter making their total number for the digestive tract about ten millions.

Histologically, a villus is a projection of the tunica mucosa (Fig. 1703) covered with a single layer of columnar epithelium, which rests upon a basement membrane, and encloses a network of blood-vessels, one or more lymphatics, and nerves; the whole being held together by a network of reticular connective tissue in the mesh of which numerous lymphoid cells are found and strands of smooth muscle in the larger trabeculæ (Fig. 1704).

*Histological Development of the Villi Intestinales.*—As has been stated on page 576 the epithelium of the digestive tract arises from the endoderm. At first the inner surface of the tract is smooth, but in the second month of embryonic life the epithelium proliferates rapidly and the lumen of the intestine becomes obliterated by a compact mass of epithelial cells. The completeness of this occlusion and the length of time it

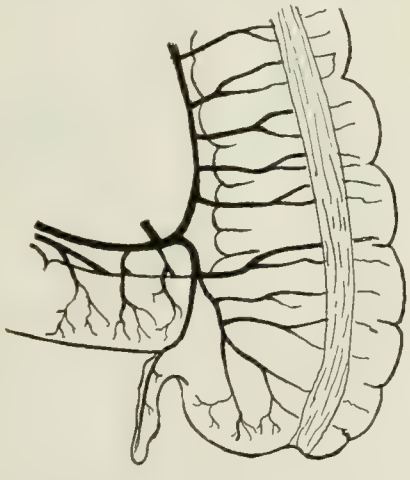


Fig. 1701.—Arteries of the Ileocecal Angle Viewed from Behind. (After Bonamy, Broca, and Beau.)

persists varies in different embryos. It is usually present in embryos of from ten millimeters to twenty millimeters in length.

This solid stage is followed by one in which irregular vacuoles appear in the epithelial mass; by the confluence of these vacuoles the permanent lumen of the intestine is formed.

At the beginning of the third month of embryonic life folds are developed in the epithelium which run lengthwise of the intestine for a longer or shorter distance (Fig. 1705). These folds represent an early stage in the development of the villi; for, when the embryo has reached a length of about sixty millimeters, these folds become constricted transversely into villi (Fig. 1706).

Berry states that at the time the folds become pronounced in the duodenum, in the ileum they are scarcely perceptible, that when the villi are present in the duodenum the folds are becoming well developed in the ileum, and that when villi alone are

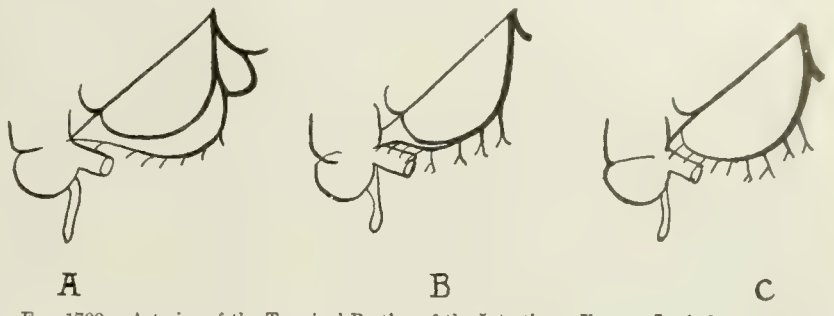



Fig. 1700.—Arteries of the Terminal Portion of the Intestinum Ileum. In *A* the artery of the ileocecal angle takes no part in the vascular supply of the ileum. In *B* it partially supplies the ileum. In *C*, through its anastomosis with the arteria mesenterica superior, it furnishes the greater portion of the arterial supply of the ileum. (After Corsy and Aubert.)

present they are more numerous in the duodenum than in the ileum. The later work of Fossner confirms the statements of Berry (Fig. 1705).

Oppel, in his summary of the comparative anatomy and evolution of the villi, has shown that in vertebrates of low order the intestine is smooth, but as we

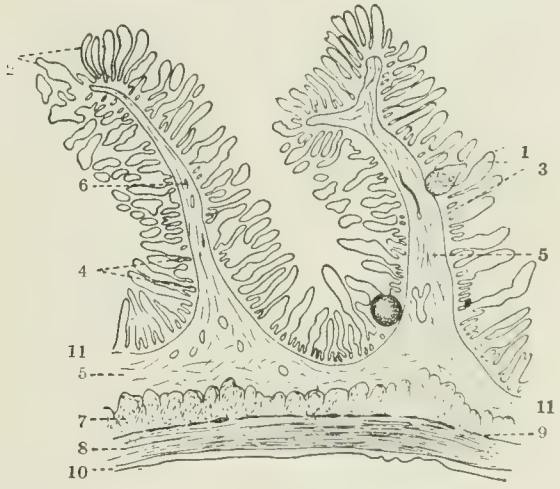



Fig. 1702.—Outline Drawing of a Longitudinal Section through the Adult Human Intestinum Jejunum, showing two Plicæ Circulares. 1, Epithelium; 2, villi; 3, lamina propria of the tunica mucosa; 4, glandulæ intestinales; 5, tela submucosa; 6, plica circularis; 7 and 8, stratum circulare and stratum longitudinale of the tunica muscularis; 9, plexus myentericus; 10, tunica serosa; 11, lamina muscularis mucosæ. The right plica circularis has two noduli lymphatici solitarii situated in the tunica mucosa external to the lamina muscularis mucosæ. The irregular outlines external to the villi are sections of villi which, because of their oblique direction, were not cut through their entire length and therefore are not attached to the tunica mucosa. × 10. (After Stöhr.)

ascend the vertebrate phylum we find longitudinal folds which finally give way to villi and that the villi first appear in the anterior part of the intestine and gradually extend backward.

Johnson, in his recent study of the development of the villi, says: "Only in the lower part of the small intestine was I able to find distinct longitudinal folds

preceding the formation of villi. In the upper two-thirds of the small intestine, villi are found developing as knob-like invaginations of the epithelium."

In his study of the intestinum crassum, Johnson found that the formation of folds preceded the formation of villi. The folds first appeared in the intestinum rectum and grew orally. A second point of growth was found in the colon ascendens which grew aborally. The colon transversum is the last portion

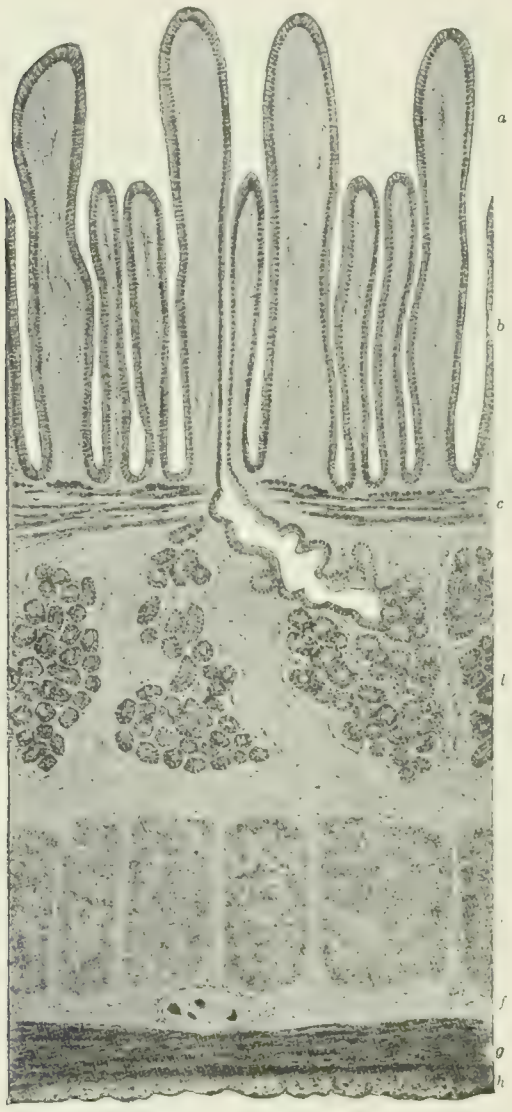



FIG. 1703.—Longitudinal Section of the Duodenum of the Cat. *a*, Villi intestinales; *b*, glandulæ intestinales; *c*, lamina muscularis mucosæ; *d*, glandulæ duodenales; *e*, stratum circulare of the tunica muscularis cut transversely; *f*, intermuscular layer of connective tissue; *g*, stratum longitudinale of the tunica muscularis cut longitudinally; *h*, tunica serosa. × 60. (After Schäfer.)

of the intestinum crassum to acquire ridges and folds. Villi were formed by segmentation of these folds. The villi reached their maximum growth in embryos between 110 millimeters and 140 millimeters in length. From this period of development they gradually become smaller and smaller until at birth they have entirely disappeared.

*Epithelium.*—Columnar epithelium covers not only the villi (Fig. 1703) but also the entire surface of the digestive tract; it extends into the mucosa where it lines the glandulæ intestinales (crypts of Lieberkühn).

The columnar epithelium covering the villi rests upon a basement membrane which is connected on the one hand with the stroma of the villi and on the other hand sends prolongations between the epithelial cells. The epithelium possesses on its free surface a peculiar striated border, known as the cuticular border. Various explanations have been offered for this striated appearance. Some of the older histologists considered them tubular structures; others, as indicating the presence of finger-like pseudopodia; still others as aborted cilia, the vestige of the ciliated epithelium found in the intestine of lower forms. While much can be said in favor of this last theory, the fact remains that there is not a uniformity of opinion in regard to the significance of these structures.

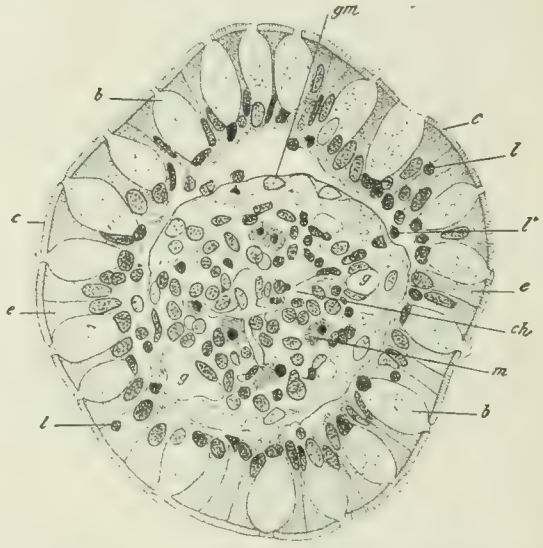



FIG. 1704.—Transverse Section of a Villus from the Human Intestinum Tenue. *b*, Goblet cells, some of which are discharging their contents; *e*, columnar epithelium; *c*, striated, cuticular border of the epithelium; *l*, leucocytes between the epithelial cells; *l'*, leucocytes below the epithelium; *m*, smooth muscle cell cut transversely; *ch*, central lymphatic; *gm*, basement membrane with its nuclei somewhat shrunken away from the epithelium. × 530. (After Kölliker.)

Throughout the entire digestive tract, goblet cells are found intermingled with the columnar epithelial cells. Goblet cells (Fig. 1707) are columnar epithelial cells in which the protoplasm of the outer half has undergone a special metamorphosis and been converted into mucigen. As this accumulates within the cell it becomes more and more distended until finally it ruptures the cell and is discharged from its free border into the lumen of the intestine as mucus. While these changes have been taking place in the outer portion of the cell the remains of the protoplasm and the nucleus have been pushed toward the narrow base of the cell.

With the discharge of its contents the goblet cell collapses and appears as a thin nucleated structure between the columnar epithelial cells. It is generally stated that goblet cells can regenerate after discharging their contents. This is especially true of goblet cells found in the tunica mucosa of the trachea; in the intestine, however, it is probable that most of them are shed off after discharging their contents.

Beside these goblet cells numerous leucocytes are found between the epithelial cells covering the villi. Some of them, no doubt, find their way into the lumen of the intestine, but the larger number play an impor-

tant part in the transportation of fat particles and other food substances to the lymphatics.

*Mucosa Proper.*—The mucosa proper consists of a connective-tissue stroma in which a large number of glands (glandulæ intestinales) are embedded.

Histologically the stroma resembles that of lymph nodes and contains not only the usual constituents of connective tissue but also a considerable amount of reticulum. Prolongations of this stroma form the framework of the villi. A larger number of lymphoid cells are present, proportionally, in the mucosa proper than in the villi; sometimes they form a distinct layer about the fundus of the glands, known as the granular layer.

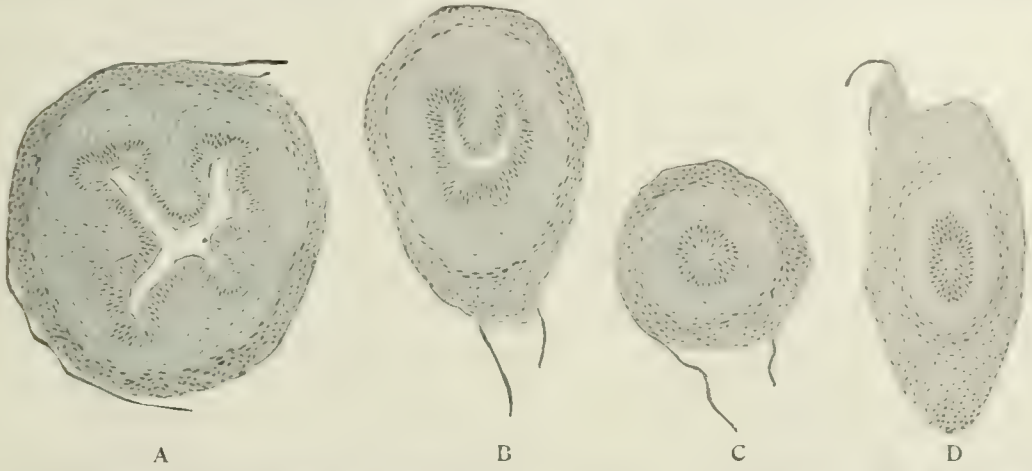



Fig. 1705.—Transverse Sections through the Intestine of a Human Embryo 21.1 mm. in length. × 80. *A*, Through the duodenum; *B*, through the jejunum; *C*, through the ileum; *D*, through the colon. (From Broman after Forssner.)

The glandulæ intestinales (Fig. 1703) are formed by invaginations of the epithelium covering the surface of the intestine. They open into the intervals between the bases of the villi. The epithelium of the glands rests upon a thin homogeneous basement membrane and is continuous with that covering the villi and possesses many of its characteristics. Those cells nearest the villi have a distinct columnar shape and a striated cuticular border. In the deeper portion of the glands the cells become conical in shape and lose their cuticular border. This change in shape is probably occasioned by the curvature of the fundus of the glands. Between the gland cells goblet cells are found in various stages of development. According to Bizzozero there is a constant shedding of epithelium from the surface of the villi; the shed epithelium being replaced by new cells which are pushed up from the fundus of the glands where cell division is actively taking place.

In the fundus of the glands a third type of cells is found, known as the cells of Paneth. These cells contain numerous granules which stain readily with eosin or iron-hematoxylin. The function of these cells has not as yet been definitely determined.

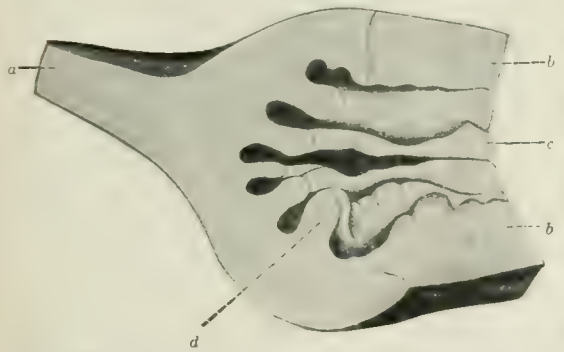



Fig. 1706.—Reconstruction Model of the Intestinum Tenue of a Human Embryo 28 mm. in Length in which the Longitudinal Folds are being Constricted into Villi. *a*, Mesenterium; *b*, intestinal wall cut longitudinally; *c*, longitudinal fold; *d*, longitudinal fold in which villi are being formed by constriction. (From Broman after Berry.)

*Glandulæ. Duodenales.*—The glandulæ duodenales (Brunner's glands) as their name implies, are confined to the duodenum. They are tubulo-alveolar glands and are found most abundantly in the first fifty millimeters of the duodenum gradually decreasing in size and number until at the distal end they are generally wanting. They are situated, for the most part, in the tela submucosa (Fig. 1703). We find, therefore, two types of glands in the duodenum, the one superimposed over the other; the glandulæ intestinales in the tunica mucosa and the glandulæ duodenales in the tela submucosa.

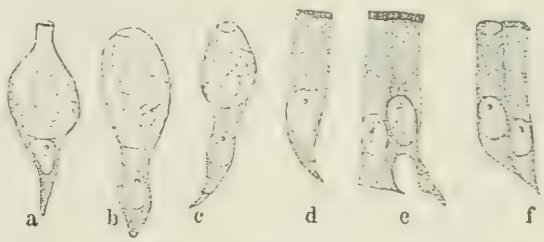



Fig. 1707.—Isolated Epithelial Cells from the Human Intestine. *a*, *b*, *c*, Various forms of goblet cells; *d*, *e*, *f*, epithelial cells showing the striated cuticular border. × 525. (After Schiefferdecker and Kossel.)

The glandulæ duodenales may be considered as direct continuations of the glandulæ pyloricæ into the duodenum, since they correspond in all essential structural details. In the pars pylorica of the ventriculus we find the glandulæ pyloricæ situated above the lamina muscularis mucosæ; but, as we follow these glands in longitudinal sections which include the valvula pylorici and upper part of the duodenum, we find them breaking through the lamina muscularis mucosæ and finally situated beneath the lamina muscularis mucosæ in the tela submucosa. Their excretory ducts pierce the lamina muscularis mucosæ and open into the fundus of the glandulæ intestinales,

or they penetrate the tunica mucosa and open on the surface of the intestine. The secretion of these glands is mucus (Bensley).

*Noduli Lymphatici.*—In addition to the diffused lymphoid tissue already described as being found in the tunica mucosa, circumscribed nodules, either isolated or collected into masses of considerable size, are found scattered over the tunica mucosa in all parts of the intestinum tenue. The isolated masses are termed noduli lymphatici solitarii (solitary glands); the collected masses are termed noduli lymphatici aggregati (Peyer's patches). These nodules are more numerous in young persons than in old individuals. Diminution of lymphoid tissue in the digestive tract is one of the concomitant changes of old age.

Fig. 1708.—Transverse Section through a Nodulus Lymphaticus Aggregatus from the Intestinum Tenue of a Cat. *a*, Lymph nodules; *b*, tela submucosa; *c*, lamina muscularis mucosæ; *d*, villi; *e*, glandulæ intestinales; *f*, tunica muscularis with its stratum longitudinale (*g*) and its stratum circulare (*h*). × 7. (From Oppel after Stöhr.)

*Noduli Lymphatici Solitarii.*—The term "gland" formerly applied to these structures was a misnomer since they in no way resemble a gland, but correspond in structure and function to the cortical nodules or follicles of a lymph node. The noduli lymphatici solitarii are pyriform-shaped masses of lymphoid tissue, which may or may not possess a germ center, situated in the tunica mucosa, the bases of the nodules resting upon the lamina muscularis mucosæ. When the nodules are of large size they often push their way through the lamina muscularis mucosæ into the tela submucosa. Villi are absent over the apex of the nodules and the glandulæ intestinales are pushed to one side (Fig. 1702).

Each nodule is surrounded by a network of blood-vessels which sends numerous capillaries into its substance. It is also surrounded by a rich plexus of lymphatics, but no lymphatics pass into the substance of the nodules. The noduli lymphatici solitarii are less numerous in the upper part of the digestive tract than in the middle and lower portion.

*Noduli Lymphatici Aggregati.*—As the seat of the chief lesion in typhoid fever these collections of lymphoid tissue are of special interest pathologically as well as histologically. The noduli lymphatici aggregati, formerly called the agminated glands or Peyer's patches, are oblong groups of lymph follicles. They vary in length from twelve to one hundred millimeters and are about twenty-five millimeters wide. They are situated along the free border of the intestine, their long axis corresponding to the long axis of the intestine. There are usually from twenty to thirty of these nodules, but in young persons they may be more numerous. They are larger and more closely placed in the lower part of the ileum and they sometimes form nearly a ring about the valvula coli. In the upper portion of the jejunum and in the duodenum they are less frequent, smaller, and of a more circular outline. In the upper portion of the duodenum, close to the valvula pylorica there is usually a well-developed nodule. This is often overlooked; but, in the original description of these structures, Peyer figures and describes this particular "patch."

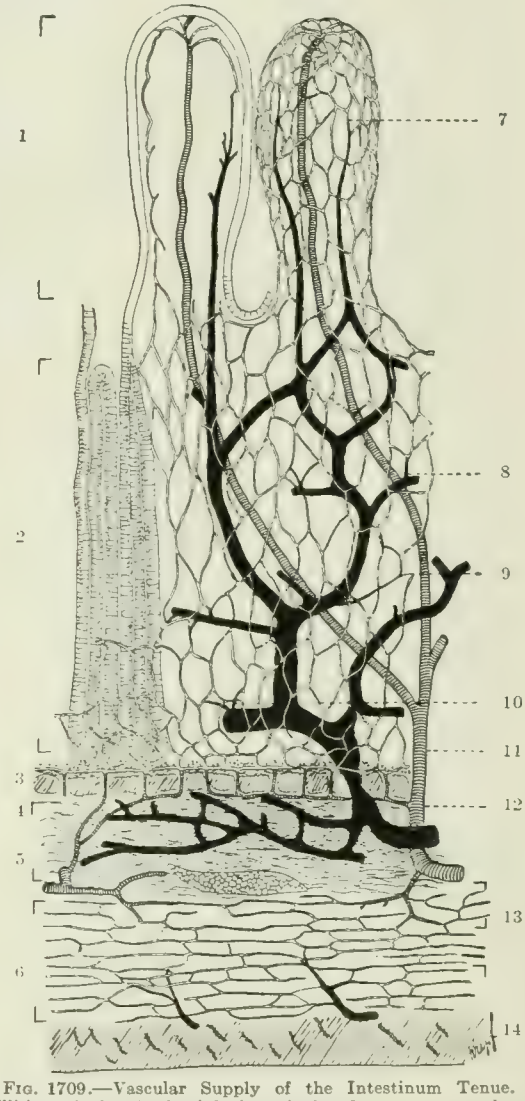



Fig. 1709.—Vascular Supply of the Intestinum Tenue. **1**, Villi intestinales; 2, glandulæ intestinales; 3, stratum granulosum; 4, lamina muscularis mucosæ; 5, tela submucosa; 6, tunica muscularis; **7**, superficial veins of the villi; 8, superficial veins of the glandular layer of the tunica mucosa; 9, middle veins of the glandular layer of the tunica mucosa; 10, deep veins of the glandular layer of the tunica mucosa; 11, artery distributed to the villi intestinales; 12, arteries passing to the glandulæ intestinales; 13, arteries distributed to the tunica muscularis; 14, blood-vessels situated between the two laminæ of the tunica muscularis. (From Oppel, after Mall.)

The plicæ circulares stop at the margin of the noduli lymphatici aggregati and do not extend across them. Villi are found between the lymphoid nodules but not directly over them (Fig. 1708).

The relations of the blood-vessels and lymphatics to the noduli lymphatici aggregati are the same as for the noduli lymphatici solitarii. The lymphatics often form a sinus about each type of the noduli lymphatici.

*Arteries.*—The gross distribution of the artery to the intestine has already been described. From the encircling arteries situated in the tunica serosa smaller branches penetrate through the tunica muscularis into the tela submucosa in which they branch freely. As the artery crosses the tunica muscularis numerous branches are given off to the stratum longitudinale and to the stratum circulare which break up into capillary networks which are arranged parallel to the long axis of the smooth muscle cells. In transections of the intestine, therefore, we find the network cut longitudinally in the stratum circulare but more or less transversely in the stratum longitudinale (Fig. 1709).

From the arterial network in the tela submucosa two sets of arteries pass to the tunica mucosa. The larger of these arteries, the artery distributed to the villi, penetrates the lamina muscularis mucosæ and divides into branches which pass without further branching to a villus (Fig. 1709). The smaller of these arteries, the crypt artery (Fig. 1709) runs parallel to the lamina muscularis mucosæ, between it and the tela submucosa, and sends off branches which penetrate the lamina muscularis mucosæ and break up into a capillary network about the crypts (glandulæ intestinales).

There is usually a single artery for each villus. When this is the case it may be situated in the center of the villus or it may be at one side. In villi which are broad and leaf-like there may be more than one artery distributed to a villus or the single artery passing to a villus may divide into one or more branches.

*Veins.*—When the artery passing to a villus is situated in the center of the villus it usually passes without branching to its most distal part and then suddenly breaks up into fifteen or twenty capillaries which unite to form two venous radicles situated one on either side of the villus (Fig. 1709). When the artery is situated on one side of the villus we can usually distinguish an arterial and a venous side of the villus.

The capillary network arising from the arteries of the villi unite in the deeper part of the tunica mucosa with that into which the crypt artery breaks up and these again unite to form a venous plexus which is situated in the glandular layer of the tunica mucosa (Fig. 1709). No valves are present in these veins but just as they penetrate the lamina muscularis mucosæ they become constricted and again dilate as soon as they reach the tela submucosa. It is not improbable that the lamina muscularis mucosæ exerts a sphincter-like action on the veins as they pass through it.

Within the tela submucosa the veins form a second plexus. The venous trunks arising from this plexus pass out nearly parallel to the artery and join the mesenteric veins. The capillaries within the tunica muscularis not infrequently unite to form small veins which either join the main venous branch or pass directly to the mesenteric veins. The latter course is quite frequently found along the attached border of the intestine.

*Lymphatics.*—The lymphatics of the small intestine, often termed lacteals, arise in the villi (Fig. 1710, A). In the long finger-like villi they begin in a club-shaped dilatation which gradually tapers into a single vessel which occupies a central position in the villus. In the broad leaf-like type there may be two or three lymphatics which are connected by terminal loops. The lymphatics coming from the villi break up at the base of the villi into a plexus. From this plexus straight vessels penetrate the glandular portion of the tunica mucosa and form a second plexus about the base of the glands; the subglandular plexus. From this subglandular plexus branches penetrate the lamina muscularis mucosæ to form, in the tela submucosa, a third plexus; the submucous plexus. A fourth plexus is formed in the tunica serosa by branches coming from the submucous plexus. As these branches pass through the tunica muscularis they are joined by other lymphatics coming from the intramuscular network, and the trunks thus formed join the lymphatics of the mesentery which enter the large lymphoglandulæ mesentericæ near the back of the mesentery. Neither the noduli lymphatici solitarii nor the aggregati contain lymphatics, but they are encircled at their periphery by a network of lymphatic capillaries. Distal to the submucous plexus no valves are present in the lymphatics; the vessels leaving this plexus, however, are provided with numerous valves. When collapsed the lymphatics are seen with difficulty, but when filled they are easily recognized by the milky appearance of their contents (chyle).

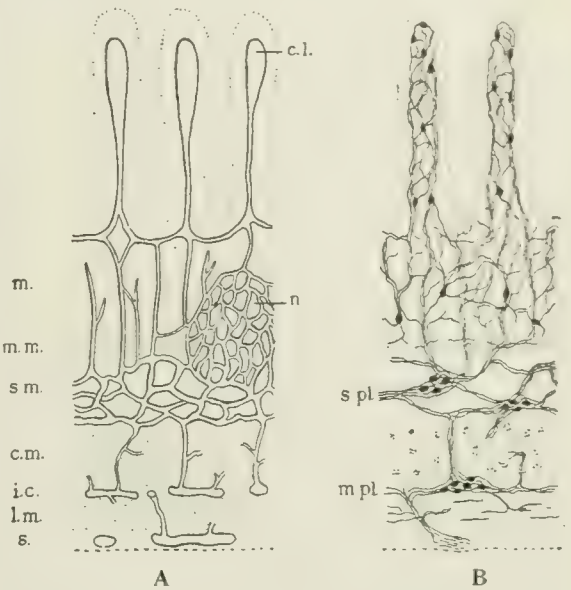



FIG. 1710.—*A*, Diagram of the Lymphatics (after Mall). *B*, Diagram of the nerves (after Cajal). *m*, Tunica mucosa; *mm*, lamina muscularis mucosæ; *sm*, tela submucosa; *cm*, and *lm*, stratum circulare and stratum longitudinale of the tunica muscularis; *ic*, intermuscular connective tissue; *s*, tunica serosa; *cl*, central lymphatic; *n*, plexus of lymphatics around the periphery of a lymph nodule; *mpl*, plexus myentericus; *spl*, plexus submucosus; from this latter plexus the nerves can be followed into the tunica mucosa and villi. (From Stöhr.)

*Nerves.*—The nerves distributed to the intestinum tenue are derived from the sympathetic nervous system. Branches from the plexus mesentericus superior accompany the larger branches of the mesenteric artery. As they approach the intestine they leave the blood-vessels and penetrate the tunica muscularis. After piercing the stratum longitudinale they form a gangliated plexus which is spread out in the connective tissue between the stratum longitudinale and the stratum circulare of the tunica muscularis (Fig. 1710, B). From this plexus, the plexus myentericus or Auerbach's plexus, branches are distributed to both layers of the tunica muscularis. Larger branches are continued through the stratum circulare into the tela submucosa where they form a second gangliated plexus, the plexus submucosa or Meissner's plexus (Fig. 1710, B). From the plexus submucosa branches are distributed to the lamina muscularis mucosæ; other branches pass through this layer and form a fine nerve plexus in the tunica mucosa and within the villi.

INTESTINUM CRASSUM.—The intestinum crassum has, like the intestinum tenue, four coats, viz., tunica serosa, tunica muscularis, tela submucosa, and tunica mucosa.

*Tunica Serosa.*—The tunica serosa is similar to that

of the intestinum tenue except that along the colon, where appendices epiploicæ are present, it is prolonged over their surface. It is usually incomplete on the

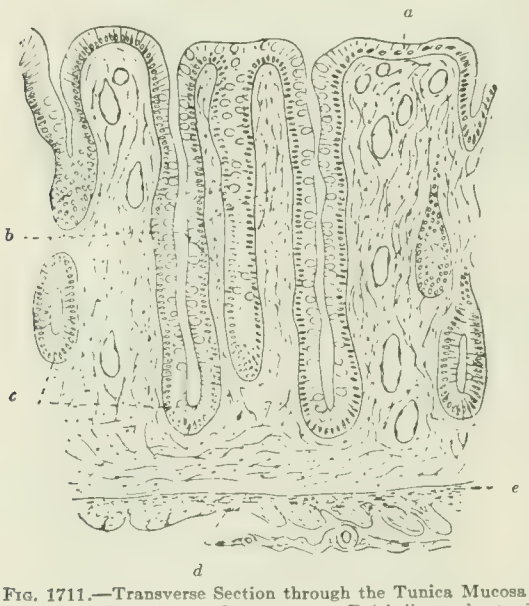



Fig. 1711.—Transverse Section through the Tunica Mucosa of the Human Intestinum Crassum. *a*, Epithelium; *b*, tunica propria; *c*, glandulæ intestinales; *d*, tela submucosa; *e*, lamina muscularis mucosæ. × 90. (From Oppel after Brass.)

posterior and mesial surfaces of the colon ascendens, of the colon descendens, and of the first part of the colon sigmoideum.

*Tunica Muscularis.*—The tunica muscularis consists of a lamina longitudinalis and a lamina circularis. The lamina longitudinalis differs from that of the intestinum tenue in that, although it completely surrounds the intestine, the greater part of it is collected into three prominent bands, the tæniæ coli. These bands begin at the attachment of the processus vermiformis to the intestinum cecum and can be traced along the entire length of the colon. One band extends along the attached border of the colon (tænia mesocolica); a second band extends along the border which corresponds in the colon transversum with the attachment of the omentum majus (tænia omentalis); the third band is equidistant from the other two (tænia libera). The tæniæ coli are shorter than the intervening part of the colon; as a result of this shortening the colon is thrown into sacculations, the haustra coli. The folds resulting from this sacculation in the interior of the colon, are called the plicæ semilunares coli. If the tæniæ coli are dissected off, the sacculations are entirely effaced. The lamina circularis, except that it is thinner, differs in no respect from that of the intestinum tenue.

The tela submucosa corresponds in structure to that of the intestinum tenue.

*Tunica Mucosa.*—The tunica mucosa (Fig. 1711) differs in several respects from that of the intestinum tenue. Villi are absent and the glandulæ intestinales are longer and contain a greater number of goblet cells. In some of the glands nearly every alternate cell is a goblet cell.

The lamina muscularis mucosæ and the tunica propria have the same structure as in the intestinum tenue. Noduli lymphatici solitarii are found scattered over the tunica mucosa; only the larger nodules extend through the lamina muscularis mucosæ into the tela submucosa.

*Blood-vessels.*—Owing to the absence of villi the vascular supply of the intestinum crassum corresponds more closely to that of the ventriculus than to that of the intestinum tenue. The artery penetrates into the tela submucosa and from its arborization in this layer branches penetrate into the tunica mucosa where they break up into a capillary network about the glandulæ intestinales. This network forms on the surface of the tunica mucosa a plexus of veins which surrounds the mouths of the glands. From this plexus straight branches arise which pass through the tunica mucosa into the tela submucosa where they unite to form the main venous trunks. The further arrangement of the blood-vessels is the same as in the intestinum tenue.

*Lymphatics.*—The absence of villi modifies the distribution of the lymphatics as well as that of the blood-vessels. In the place of arising in ampullæ, they arise from a superficial plexus situated in the tunica mucosa. From this plexus branches pass through the tunica mucosa into the tela submucosa where they unite and form the main lymphatic trunks; these in turn pass to the lymphoglandulæ mesocolicæ.

*Nerves.*—Except that there are no villi to be supplied the distribution of the nerves is the same as in the intestinum tenue.

*Processus Vermiformis.*—The processus vermiformis, or vermiform appendix, is an irregular worm-like appendage connected with the intestinum cecum. It is from eight centimeters to eight and one-half centimeters in length and about six millimeters in diameter. It corresponds in structure with the intestinum crassum. The lamina circularis of the tunica muscularis is rather more than twice the thickness of the lamina longitudinalis. The tunica mucosa is thrown into longitudinal folds, in consequence of which the lumen of the appendix is very irregular in outline.

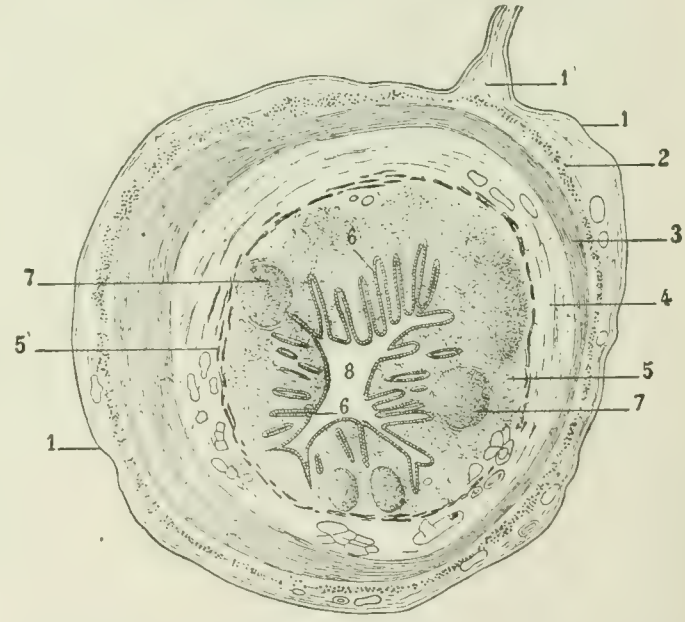



Fig. 1712.—Transverse Section of the Processus Vermiformis. 1, Tunica serosa with its continuation into the meso-appendix at 1'; 2, lamina longitudinale of the tunica muscularis; 3, lamina circulare of the tunica muscularis; 4, tela submucosa; 5, tunica mucosa; 5', lamina muscularis mucosæ; 6, glandules intestinales; 7, noduli aggregati processus vermiformis; 8, lumen of the processus vermiformis. (After Testut.)

The tunica mucosa contains a large amount of lymphoid tissue which is collected into numerous lymph nodules which contain germ centers. These nodules often form a continuous mass which encircles the appendix; the noduli aggregati processus vermiformis (Fig. 1712).

The glandulæ intestinales contain a large number of goblet cells. With advancing age the amount of lymphoid tissue diminishes and the appendix undergoes more or less atrophy accompanied with obliteration of its lumen.

The distribution of the blood-vessels, lymphatics, and nerves within the processus vermiformis corresponds to that of the intestinum crassum. The lymphatics of the appendix pass to the lymphoglandulæ ileocecales. Clado has described anastomoses, in the female, between the lymphatics of the appendix and the lymphatics of the right ovary.

*Intestinum Rectum.*—In the intestinum rectum the following variations in structure from that of the colon may be noted. At the upper part of the rectum the tæniæ coli unite to form two bands which pass downward, the one on the anterior and the other on the posterior surface of the rectum. The plicæ semilunares coli are absent. The lamina circularis of the tunica muscularis in the lower part of the rectum forms a thickened layer which becomes developed into a sphincter muscle, some four millimeters in thickness, around the pars analis recti—the sphincter ani internus. Permanent longitudinal folds of the tunica mucosa, the columnæ rectales, are found in the lowest part of the rectum. Three permanent transverse folds are also found in the interior of the rectum, the plicæ transversales recti.

Scattered over the surface of the tunica mucosa are minute depressions, the rectal pits of Cunningham, at the bottom of which noduli lymphatici are found.

*Blood-vessels.*—The intestinum rectum receives its arterial supply from the arteria hæmorrhoidalis superior, media, and inferior. The general arrangement of both arteries and veins within the rectum is essentially that of the colon, except that the veins form two plexuses of large vessels devoid of valves: (1) the plexus hæmorrhoidalis internus, situated in the tela submucosa and provided with ampulla-like dilatations in the region of the annulus hæmorrhoidalis; (2) the plexus hemorrhoidalis externus, situated upon the external surface of the tunica muscularis.

*Nerves.*—In addition to the nerve supply from the sympathetic system, the rectum receives branches from the anterior roots of the second and third sacral nerves.

At the anus the transition of the tunica mucosa into the skin takes place. The glandulæ intestinales and the columnar epithelium disappear and are replaced by a narrow band of stratified squamous epithelium which fuses with the skin. Just external to the anus numerous highly developed sweat glands are found, the circumanal glands of Gay.

W. S. Miller.

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**Digipuratum** is a standardized extract of digitalis, the active principles of which are soluble in alkalies, but insoluble in cold water and acids. It is said to contain four per cent. of digitalin, 0.4 per cent. of digitoxin, and to be free from digitonin. It is prepared in tablets, each of which is said to be equal to one and one-half grains (0.1) of digitalis leaves. For action and uses, see *Digitalis.*

R. J. E. Scott.

**Digitalis.**—Foxglove. The dried leaves of *Digitalis purpurea* L. (fam. *Scrophulariaceæ*) (U. S. P.). Not more than two per cent. of the stem bases should be present. The British Pharmacopœia specifies "from plants beginning to flower." The German Pharmacopœia requires them to be collected from wild plants in bloom. Other definitions have specified "in full bloom" or even the entire herb in some specified stage of maturity. At present, all these definitions agree in the one important point that the leaves only are employed, the constituents of the flowers and seeds differing in character and properties, and being thus properly excluded. All things considered, the specification of the flowering stage as the time for collection is wise, as the allowance of a very much earlier or very much later period gives no guarantee of the desired quality. There is also little doubt that the wild-grown leaves are usually more active than those of cultivation, though the difference is commonly overestimated. The belief, long prevalent, that leaves of the first year's growth are very inferior, is now mostly abandoned.

The plant is very abundant, except in the coldest parts, throughout Europe, besides which it is largely cultivated. It reaches its greatest physical perfection in our northwestern coast States, where it is extensively naturalized along roadsides, attaining a height of ten and even twelve feet. Ordinarily it reaches a

height of from two and one-half to four feet, one or more usually simple, erect stems arising from a rosette of radical leaves which replaces a similar rosette produced, with the stout conical or fusiform root, during the first year. Upon the stems, the leaves become smaller toward the top, and are finally reduced to large floral bracts. The handsome, drooping, bell-shaped, purple flowers, spotted within with darker purple, are racemed along one side of their stems, generally for more than half their length.

The drug usually comes in bales, sometimes pressed into hard cakes or blocks of different sizes. Some very finely selected leaves are powdered abroad and are imported in small expensive packages, specially for administration in powdered form. The drug is from ten to thirty centimeters long; ovate or ovate-oblong, narrowed into a petiole; crenate; dull gray, green, densely and finely pubescent; wrinkled above; paler and reticulate beneath; midrib near the base broad; odor slight, somewhat tea-like; taste bitter, nauseous.

Fig. 1713.—Digitalis Purpurea Linn., Foxglove. Plant in blossom, flower slightly reduced in size, and section of flower natural size. (Baillon.)

No other leaf probably offers greater difficulties in the matter of quality selection, and little assistance can be gained from written instructions, success coming only from long experience. This is the more unfortunate, as there is no satisfactory method of assay.

Composition.—The active constituents of digitalis are crystalline glucosides. With them, there occur resin, tannin, gum, pectin, a little sugar, and digitaleic acid. Concerning the nature and occurrence of the glucosides, the discrepancy between the statements made by different investigators is so great as to preclude instructive discussion here.

"*Digitalin*," as dispensed, is very uncertain. Not only is it usually a mixture, but the supposedly chemical body, so called, is not of a uniform character, as supplied by different manufacturers; hence, the only successful way of employing it is to use exclusively the product of the same manufacturer, and learn its therapeutic limitations. It is said by some investigators that true digitalin does not occur in the leaves, but only in the seeds; however, a substance practically identical with it does occur, and we need not consider this point. Of the formula, Merck says "$(C_5H_8O_3)N$ (?)," and he lists a "German" and a "French" product, both from *Digitalis purpurea*, but the part of the plant not stated. The former is a yellowish-white powder, soluble in water and alcohol. The dose is given as 0.001 to 0.002 gm. (gr. $\frac{1}{64}$–$\frac{1}{32}$), three or four times a day and not to exceed gr. $\frac{1}{4}$ daily. The French article is similar, soluble in alcohol, but only in 2,000 parts of water. The dose is gr. $\frac{1}{2}\frac{1}{0}$ which may be increased to a maximum of gr. $\frac{1}{4}\frac{1}{0}$ daily. Both these solutions have the characteristic action of digitalis upon the heart.

*Digitoxin* ($C_{21}H_{23}O_7$?) is the most abundant, as well as the most active constituent. It is a white crystalline powder, soluble in alcohol, but not in water, although, by virtue of the associated bodies in the leaves, it is extracted by the infusion. The dose is gr. $\frac{1}{2}\frac{1}{5}\frac{1}{0}$–$\frac{1}{1}\frac{1}{2}\frac{1}{5}$ three times a day, and it is recommended that chloroform ♏ij., alcohol fl. ℥i., and water ℥ iss, be taken with it. The maximum amount for the day is gr. $\frac{1}{3}\frac{1}{2}$. As an enema, gr. $\frac{1}{3}\frac{1}{0}$, with alcohol ♏x. and water fl. ℥iv., is recommended.

*Digitonin* ($C_{31}H_{52}O_{17}$?). The presence of this in the leaves is denied. However, it is similar to saponin, and in the doses of digitalis its action is not appreciable. The same is true of digitin $(C_4H_3O_2)N$. *Digitalein* is a mixture.

Action.—The different ways in which digitalis acts upon the organs may first be considered.

1. It stimulates the muscular fibers in the cardiac and arterial walls, thus increasing cardiac force and in a double way raising blood pressure.

2. It stimulates the nerve tissues in the heart (at least the nerve endings, the action upon the ganglia being doubtful) and in the arteries, thus increasing the above-mentioned effects, but at the same time beginning to slow the heart by stimulating the ends of the vagus.

3. It stimulates the centers in the brain and cord, thus greatly increasing the slowing of the heart and still further increasing its force.

As the effects of the drug are such as just enumerated, it follows that well-regulated doses will restore rhythm to an irregular heart. It is probably due to this stimulation of the vagus that digitalis relieves cardiac irritability resulting from overexertion. When high fever exists, this slowing of the heart is less apt to take place. The effects of the above-described actions have to be very carefully considered in determining the use of the drug. Its action is characteristically slow in coming on, requiring usually several hours, and the effects are similarly slow in passing off, so that when great promptness is required, digitalis is not available. One feature of the slow heart beat produced by this drug is an extension of the space required in the diastolic condition; hence when there are great accumulations of fluid encroaching upon the heart space, we must be cautious in our use of digitalis.

A more important consideration is the difference of digitalis from other cardiants in its powerful stimulation of the arterial walls. This prevents the heart strengthening from resulting in a clear gain (especially in view of its slowness), for resistance is at the same time increased. Since the increased heart action depends upon the muscular cardiac walls, it cannot so well take place when these are weakened by dilatation or fatty degeneration, or when there is aortic regurgitation, for here we simply increase resistance more than we do heart strength and thus favor backing up of the blood into the heart. Unless we can then relax the vessels in some way, it is better to substitute some other cardiant. Experiments made on pigs by Hare

go to show that by administering digitalis carefully, increasing the dose gradually until large amounts are taken, we may bring about a great and permanent increase in the size and quality of the muscle of the healthy heart. If it shall be found, upon further trial, that this same effect can be produced in the case of a dilated heart, it can readily be appreciated how far this result will exceed all our past anticipations with regard to the usefulness of digitalis.

The next most important effect of the drug is upon the kidney. It is a recognized principle that increased blood pressure favors increased renal secretion, which alone would account for the diuretic properties of digitalis; but in addition, there is a direct renal stimulation effected by irritation and by locally contracting the vessels, thus inducing an even greater local increase of blood pressure. This occurs the more easily because the substance is almost wholly excreted through the kidney. This presentation of the modus operandi of the drug is subject to certain modifications. The excessively stimulating effect upon the kidney often results in an overcontraction of the renal vessels, which checks secretion. As this state passes off, a profuse secretion comes on very suddenly. If this change does not promptly take place, the digitalis checks its own excretion and continues in the circulation, becoming cumulative in a way very different from its cumulative action upon the heart muscle already considered, and is liable to become poisonous. In a state of health, the diuretic effect of digitalis is not usually pronounced, unless the blood pressure is unusually low (Brunton).

The other actions of digitalis are not important, except that it is very likely to irritate the stomach and intestines; this is especially true when the drug is given in the form of the infusion. Such irritation may add to the nausea or vomiting which is often caused by disturbance of the cerebral circulation; it may also produce a laxative or even a purging effect. The cerebral disturbance may also cause dizziness, headache, disordered sight, and hearing. The uterus is stimulated. The slight antipyretic effects which digitalis produces are probably dependent upon the lessened circulation induced by slowing of the heart.

Toxicology.—The symptoms of poisoning by digitalis are a feeling of stiffness, fatigue, sleepiness, and pain in the head coming on within half an hour after a toxic dose has been taken, followed by violent vomiting, with pain in the stomach, nausea, vertigo, and syncope, the headache becoming more intense. The heart beats rapidly and violently and a sense of suffocation is felt. The pulse diminishes in frequency, and becomes irregular and difficult to count. Visual disturbances accompany the other symptoms; among them may be mentioned dimness, oscillation and inclination of surrounding objects, and even color-blindness. The pupils are usually dilated, especially if the preparation contained much digitoxin. Sometimes there are delirium and convulsions. Although the drug generally acts as a diuretic, suppression of the urine has been observed. Death may occur in coma or convulsions, but it usually takes place suddenly from syncope provoked by some slight movement.

*Treatment.*—If the patient is seen in the early stages induce vomiting by large draughts of tepid water. In a more advanced stage, if vomiting is persistent, avoid giving too much drink, and administer ice fragments, opium, or cocaine. Whiskey or nitroglycerin internally, and inhalation of amyl nitrite are to be resorted to for the purpose of checking the tendency to syncope. It is very important that the patient be kept quiet in bed, avoiding all movements. (Riggs.)

Uses.—We cannot do better than to reprint Beaumont Small's account of the uses of digitalis, as given in the supplement to a previous edition of this work.

"Digitalis maintains its position at the head of heart tonics. In England and America authorities are as one on this point. On the continent they are the same. Dujardin-Beaumetz assigns it the first rank and calls it 'the type of heart tonics'; Professor Nothnagel places it above all other heart tonics, and Herr Fürbringer says, 'the sovereign diuretic in cardiac disease has been, and still is, digitalis.' Continued use has confirmed the confidence placed in it, and the innumerable rivals that appear serve only to bring its superior qualities into bolder relief. Not much has been added to the uses of this remedy, but we know more definitely its proper sphere, and apply it with more precision to the conditions in which it will prove of value.

"In organic disease of the heart the guide for its use is the state of the compensatory action of that organ. It is not given as a remedy for the defective valves, nor with the expectation of benefiting any diseased condition of the organ; it is simply a stimulant and tonic to the muscular tissue. So long as the heart is able to overcome the impediment to the circulation and maintain a free flow of blood, nothing is to be gained by the use of the drug, but, with the earliest symptoms of failing power, its administration must be commenced. The system responds quickly to the first indication of this loss of compensation, the heart beats more feebly and quicker, the pulse becomes irregular, a slight degree of dyspnea is noticed, and edema of the feet and ankles begins. In such conditions the beneficial action of digitalis is most marked. The heart beats more slowly and forcibly and propels the blood onward, the arteries become filled, the engorged veins relieved, and the equilibrium of the circulation is reëstablished. This slower action of the heart allows of a prolonged period of diastole, during which it is at rest and recuperating; the succeeding contraction is rapid and strong, due to the renewed strength and stimulating action of the remedy.

"No form of organic disease contraindicates the use of digitalis when the compensatory action is failing. Its typical action is produced in mitral disease, in which it acts rapidly and for a prolonged period. In mitral stenosis it has been thought to produce a peculiarly important effect, as the prolonged dilatation of the ventricle permits a greater flow of blood from the auricle through the narrowed channel. In aortic disease it may also be given with confidence. The old idea that the prolonged diastole would allow the ventricle to become overfilled appears to be but little regarded now, as its beneficial effect outweighs any such danger. The following conclusions furnish the indications in accordance with which digitalis may be used not only in aortic, but in all forms of valvular disease: (1) In all cases of valvular disease the most important matter for consideration in regard to the heart itself is the condition of its walls in respect to dilatation and hypertrophy; (2) it must be remembered that the presence, in cardiac disease, of symptoms indicating a disturbance of the circulation always means failure of compensation; (3) it is important to ascertain, before administering the drug, that the condition of overhypertrophy or overcompensation does not exist; (4) it must not be forgotten that the dangers in aortic disease arise from the same cause as the dangers in mitral disease—that is, from a failure of the ventricular muscle to perform the ever-increasing work put upon it; (5) it must be admitted that if digitalis is safe and beneficial in mitral disease it is equally so in aortic disease.

"The one condition in which digitalis is contraindicated is fatty degeneration of the heart. In advanced stages of this disease, where the walls are thin and the cavities are much dilated, it must be used with extreme caution, as its action may be too violent for the feeble organ, and paralysis or rupture may follow. In the lesser degrees of degeneration, where the evidences of such a condition are indistinct, a want of action on the part of the remedy is a sign

that must not be disregarded. Dujardin-Beaumetz furnishes the following rule: 'When in a patient, digitalis, administered methodically, managed with care, produces no amelioration on the part of the heart and pulse; when, above all, the quantity of urine is not augmented, be persuaded that there is a fatty degeneration of the heart and immediately cease the employment of the remedy.'

"A cumulative action, in the sense of an accumulation of the drug in the system followed by an outburst of increased action, is no longer feared. No such condition occurs. Toxic symptoms arise only from an overdose or from its prolonged administration, and the condition of poisoning is preceded by its regular train of symptoms. The first effect of digitalis is to stimulate the vagus and the vasomotor centers, which improves the action of the heart and increases the blood pressure; this is followed by a relaxation of the vasomotor apparatus, which is first evident in the renal vessels. Up to this point the drug produces its therapeutic action, the relaxed vessels in the kidneys, with a high arterial tension and powerful heart, furnishing all the conditions requisite for a free secretion of fluid. When the drug is pushed beyond this it produces the toxic symptoms: the renal vessels are relaxed, the reduced blood pressure extends to the general circulation, the heart becomes weaker, and the circulation fails. When a fatal termination ensues it follows a continuance of this condition and ends with a failure of the heart, which is arrested in diastole. To avoid any ill effects it is safer to discontinue the drug for a few days, as soon as its action has been established; it may be administered again when required. Where the proper conditions for its use are observed there should be no danger of any toxic action; it is only when it is employed indiscriminately that any such effect arises. A case is reported where no bad result followed its use for nearly three years, thirty-five drops being given three times a day.

"The infusion appears to remain the popular preparation, particularly when its diuretic action is required. Among the French, a maceration in cold water is the favorite form in which the drug is administered, and it is considered superior to the infusion. Five grains of powdered digitalis are macerated in four ounces of cold water for from eight to twelve hours, and then filtered. The dose is one tablespoonful every two hours. The tincture is preferred by some as a diuretic; it is probably the most useful preparation when a simple tonic action is required. Osler considers that either preparation is efficient if the drug is of good quality and given in full doses—fifteen minims of the tincture, or half an ounce of the infusion, every three hours for two days, and then in reduced quantities. The subcutaneous employment of the infusion has been recommended. In this way it has been found that very small doses will act when larger doses, given in the ordinary manner, have failed. The advantage of this method over the administration by the stomach is that usually the gastrointestinal mucous membrane is in a catarrhal and edematous state and consequently absorption is prevented. It is also thought that the action is retarded and altered by the passage of the remedy through the liver. An infusion of three parts of the leaf in one hundred of water is prepared, and fifteen minims of this infusion are to be injected twice or three times a day. Good results, it is said, have followed this method of administering the drug.

"Digitalis, to be given early and in large doses, has been recommended as a means of aborting pneumonia. This treatment has been followed by Professor Petresco, of Bucharest, in a large number of cases. He uses an infusion of from one to three drams of the leaves in eight ounces of water, and gives a tablespoonful every hour. As much as gr. cxx. of the leaves has been given in twenty-four hours. He states that these large doses abort the pulmonary process, shorten the attack, and hasten convalescence. The temperature in some instances drops from 105° to 96° F., and the pulse from 120 to 35 per minute. He thinks that this treatment would act almost as a specific if it could be commenced with the attack. In no instance were there any bad results, and the more severe the attack the better the action of the large doses. The good effects are due to the increased force of the circulation in the pulmonary tissue and the prevention of stasis and congestion. This can follow only when large doses are administered as early and as energetically as possible.

"Professor R. Lepine has also employed digitalin in pneumonia with success; gr. $\frac{1}{20}$ was given in the morning and often gr. $\frac{1}{60}$ or $\frac{1}{30}$ in the evening. He does not think that it has any specific action, but finds it of great value in supporting the action of a weak and feeble heart during the course of the disease."

The following are the official preparations, and their doses: The powdered leaves are given in doses of gr. ss.–iii (0.03–0.2), and the fluid extract in the same number of minims; the extract, dose gr. $\frac{1}{8}$–ij (0.02–0.12;) the fifteen-per-cent. tincture, dose ♏v.–xxx. (0.3–2.0); the one-and-one-half-per-cent. infusion, dose fl ʒ i.–iv. (4.0–16.0). HENRY H. RUSBY.

**Diiodo-betanaphthol,** $C_{10}H_6I_2O_2$, also known as naphthol-aristol, is a yellowish green powder, with a faint odor of iodine, readily soluble in chloroform, but insoluble in water. It is one of the numerous substitutes for iodoform. R. J. E. S.

**Diiodocarbazol,** $C_{12}H_6I_2NH$, is prepared by adding iodine to diphenylimide (carbazol). It forms yellow, odorless plates; is insoluble in water, but soluble in ether, alcohol, or chloroform. It has been used as antiseptic, to replace iodoform. R. J. E. S.

**Diiodoform,** $C_2I_4$, *ethylene tetraiodide*, contains between ninety-five and ninety-six per cent. of iodine, and was introduced as a substitute for iodoform, but it is too easily decomposed to be of much therapeutic service. It is a yellow, almost insoluble powder; at first it is odorless, but on exposure to light it decomposes, and assumes a characteristic odor. Its medicinal properties are those of iodoform.

R. J. E. S.

**Dill or Dill Fruit.**—ANETHUM. "Dill-seed." The fruit of *Anethum graveolens* L. (fam. *Umbelliferæ*), a European annual, with a slender, low, branching stem and dissected leaves, and with flowers and fruits in compound non-involucrate umbels. Dill is raised in gardens as a household aromatic, and is official in Great Britain as the source of *Aqua anethi* and *Oleum anethi* of that Pharmacopœia. The description of its fruit is as follows: "Broadly oval, about one-sixth of an inch long, flat, and surrounded by a broad membranous border. It has a brown color, the membranous border being paler. The half fruits, or mericarps, are usually distinct in the fruits of commerce. Odor and taste agreeably aromatic."

Dill contains an agreeable *essential oil*, which contains from forty to sixty per cent. of *α-carvone*, together with *α-limonene*. Its action and use are exactly those of anise, caraway, and the other umbelliferous carminatives, from which it differs only very slightly in taste and odor. W. P. BOLLES.

**Dimethylacetal,** $CH_3CH(CH_3O)_2$ is similar in properties to diethylacetal (acetal, *q.v.*), but it is feebler, and is consequently given in larger doses than ordinary acetal. Mixed with chloroform, or with diethylacetal it has been suggested as an anesthetic, but it does not seem to have been much used.

R. J. E. S.

**Dimorphys.**—A synonym for the genus *Lamblia* in the flagellate Protozoa. *L. intestinalis* lives in the intestine of the mouse, rabbit, cat, dog, sheep, and man. See *Protozoa*. A. S. P.

**Dimsdale, Sir Thomas.**—Celebrated apostle of inoculation. Born in 1712 at Toydon-Garnon, England, he began the study of medicine at St. Thomas' Hospital, London, and established himself in practice at Hertford, in 1734. Seven years later, thanks to the great reputation which he had acquired as an inoculator, Catherine, Empress of Russia, sent for him to perform the operation upon herself and upon the Grand Duke Paul. The practice at once became fashionable, and Dimsdale, after inoculating the children of all the leading families at the Court of Russia, returned to England laden with all sorts of honors. It was probably at this time that the title of baron was conferred upon him. In 1780 the city of Hertford chose him as its representative in the House of Commons, and from that time forward he virtually gave up the practice of medicine. In 1781 he was again called to St. Petersburg, this time to inoculate the Emperor Alexander and the Grand Duke Constantine. He died, December 30, 1800.

Of his published writings, all of which relate to inoculation, the following are probably the more important: "The Present Method of Inoculating for the Smallpox, etc.," London, 1766; "Observations on the Introduction of a Dispensary for General Inoculation," London, 1778; and "Remarks on Dr. Lettsom's Letter on General Inoculation," London, 1779.

A. H. B.

**Dionin** is ethyl morphine hydrochloride, $C_{17}H_{17}NO.OH.OC_2H_5HCl+H_2O$, and is prepared from morphine similarly to codeine (which is methyl morphine). Dionin is a white, crystalline powder, soluble in ten parts of water and in twenty-five of alcohol, almost insoluble in ether or chloroform. It is mainly used as a substitute for morphine, but it is said to be productive of a "habit" worse than the morphine habit. In its properties it is intermediate between morphine and codeine, and has been used to allay the cough in whooping cough, in bronchial asthma and bronchitis. Dose gr. $\frac{1}{10}$–$\frac{1}{2}$ (0.006–0.03). R. J. E. S.

**Dioscorides, Pedanius.**—Very little is known about the life of Dioscorides beyond the fact that he was born in Cilicia, a district of Asia Minor, shortly before or shortly after the beginning of the present era. He was the most celebrated of the Greek writers on materia medica.

Mattioli, who flourished during the first half of the sixteenth century, published in 1565 commentaries on the six books of Dioscorides. It is said that the sales of Mattioli's book during the following twenty years reached the astonishing total of forty thousand copies. The title reads as follows: "Commentarii in VI libros Pedanii Dioscoridis, anazarbei, de medica materia, ab ipso auchore recogniti et locis plus mille ducti; etc.," Venice, 1565. There are many other editions, but this one is considered the best. The translation of Mattioli's Commentaries into French also met with great favor. Separate translations were made by Antoine du Pinet and Desmoulins, and both were published at Lyons, 1561 and 1572. ("Dict. Hist. de la Méd.") Wootton also states that Mattioli was the first physician to administer mercury internally. ("Chronicles of Pharmacy.") A. H. B.

**Diospiros.**—See *Persimmon*.

**Diphtheria.**—History.—The specific infectious disease which we now call diphtheria can be traced back almost to the Homeric period of Greek history. The Greeks believed that it had been communicated to their country from Egypt. The description of the pharyngeal and laryngeal manifestations of this disease left by Aretæus leaves no doubt that it was of diphtheria that he wrote. Galen, in his remarks on the Chironian ulcer, tells us that the pseudomembrane was gotten rid of by coughing in the laryngeal form of the disease, and by hawking in the pharyngeal type. From time to time during the next one thousand years we hear of epidemics both in Italy and in other portions of the civilized world. In 1517 we read of a malignant form of the disease raging in Switzerland, along the Rhine, and in the Netherlands. The disease now crossed to America, and in the New England States we get clear accounts of its ravages. Thus, Samuel Danforth, in 1659, lost four of his eleven children within a fortnight by a "malady of the bladders in the windpipe." In 1765, Home, a Scotchman, tried to show that "croup" and pharyngeal diphtheria were different diseases, or, in bacteriological terms, due to different microorganisns, and this subject remained under controversy until it was recently settled that, while most cases of croup were undoubtedly true diphtheria, a few were not.

Bard, an American, supported in 1771 the opposite theory from Home, considering the process the same wherever located. In this ground he was much nearer to the facts than Home. His observations upon diphtheria were very important and accurate.

In 1821, Bretonneau published his first essay on diphtheria in Paris and gave to the disease its present name. His observations were so extensive and so correct that little advance in knowledge took place until the causal relations of the diphtheria bacilli and their associated microorganisms to the disease began to be recognized. Since then the combined clinical, bacteriological, and pathological studies have sufficed to make diphtheria one of the best understood of diseases.

Bacteriology.—*The Bacillus of Diphtheria.*—In the year 1883 bacilli which were very peculiar and striking in appearance were shown by Klebs to be of constant occurrence in the pseudomembranes from the throats of those dying of true epidemic diphtheria. One year later, Löffler published the results of a very thorough and extensive series of investigations on this subject. He found the bacillus described by Klebs in many cases of throat inflammations which had been diagnosticated as diphtheria. When he inoculated the bacilli upon the abraded mucous membrane of susceptible animals, more or less characteristic pseudomembranes were produced, and frequently death or paralysis, with characteristic lesions.

All the conditions have since then been fulfilled for diphtheria which are necessary to the most rigid proof of the dependence of an infective disease upon a given microorganism—viz., the constant presence of this organism in the lesions of the disease, the isolation of the organism in pure culture, the reproduction of the essential lesions of the disease in animals and in man by inoculation with pure cultures, the failure to produce all the characteristic lesions of this disease by any other bacteria, and the additional proof of the immunizing value of the specific substances developed in animals subjected to injections of diphtheria toxin. In view of these facts we are now justified in saying that the name diphtheria should be applied, and exclusively applied, to that acute infectious disease usually associated with pseudomembranous affection of the mucous membranes which is primarily caused by the *Bacillus diphtheriæ* of Löffler. Other bacteria do, indeed, occasionally produce local lesions which simulate in one way or another those caused by the diphtheria bacillus, but none of them ever produce lesions similar in their totality to those of a characteristic case of diphtheria. As the diphtheria bacilli

have been quite fully described in vol. i., page 845, only those points will be given here which need to be more amply stated, on account of their important relations to diagnosis and treatment.

The Klebs-Löffler bacilli *stain* readily with ordinary aniline dyes, and retain fairly well their color after staining by Gram's method. When Löffler's alkaline solution of methylene blue is applied cold for five minutes or warm for one minute the bacilli from blood-serum cultures especially, and from other media less constantly, stain in an irregular and extremely characteristic way. Many of the bacilli do not stain uniformly. In many cultures round or oval bodies situated at the ends or in the central portions stain much more intensely than the rest of the bacillus. These bodies have been shown by Williams to bear much the same relations to the bacilli as nuclei do to cells. In old cultures the bacilli stain poorly and not at all in a characteristic way. The same round or oval bodies which take the methylene blue more intensely than the remainder of the bacillus are brought out still more distinctly by the Neisser stain. (See vol. i., Plate VIII., Fig. 4, and page 846.)

The Neisser stain has been advocated in order to separate the virulent from the non-virulent bacilli without the delay of inoculating animals; but in our hands, with a very large experience, neither the Neisser stain nor any other stain is capable of doing this, and none appear to me to give any more information as to the virulence of the bacilli than the usual methylene-blue solution of Löffler. In New York there are also a large number of bacilli which seem to have all the staining and cultural characteristics of the virulent bacilli, and yet are non-virulent in the sense that they produce no specific toxin. Nothing but the animal inoculations with control injections of antitoxin will separate specifically virulent from non-virulent bacilli.

*Biology.*—The Klebs-Löffler bacillus does not form spores. Its thermal death point with ten minutes' exposure is about 58° C., and with longer exposure a lower temperature; it is more easily destroyed by disinfectants than are many other bacteria. In the dry state and exposed to diffuse light, diphtheria bacilli usually die in a few days but occasionally may live for weeks; when in the dark, or protected by a film of mucus or albumin, they may live for even longer periods. The bacillus is not sensitive to cold, for I found it to retain its virulence after exposure for two hours to several hundred degrees below zero. It begins to develop, but grows slowly, at a temperature of 20° C., or even less. It grows more rapidly as the temperature rises, and attains its maximum development at 37° C.

The growth of the diphtheria bacillus upon agar presents certain peculiarities which are of practical importance in connection with cultures for diagnosis. If a large number of the bacilli from a recent culture are implanted upon a properly prepared agar plate, a certain and fairly vigorous growth will always take place. If, however, the agar is inoculated with an exudate from the throat which contains but few bacilli, no growth whatever may occur, while the tubes of coagulated blood serum inoculated with the same exudate contain the bacilli abundantly. Because of the uncertainty, therefore, agar is a far less reliable medium than blood serum for use in primary cultures for diagnostic purposes.

*Growth in Ascitic Bouillon:* Diphtheria bacilli can almost be divided into two great groups: one growing readily in bouillon, while the other scarcely grows at all when first removed from the throat. All varieties, however, develop luxuriantly when to the bouillon twenty-five per cent. ascitic fluid or blood serum is added. Lately this fact has been made use of with great success in getting pure cultures of diphtheria bacilli from throat cultures when virulence tests are desired. The ascitic bouillon is inoculated with the mixed bacteria from the original culture from the throat; after twenty-four or forty-eight hours a pellicle will develop if any diphtheria bacilli were present in the material inoculated. This pellicle will be found to be composed almost wholly of diphtheria bacilli. Plate cultures are then made and the bacilli readily isolated.

*Growth in Milk:* The diphtheria bacillus grows readily in milk, beginning to develop at a comparatively low temperature (20° C.). Thus milk having become inoculated with the bacillus from some cases of diphtheria may under certain conditions be the means of conveying infection to previously healthy persons. Though this growth takes place, the milk remains unchanged in appearance.

*Pathogenesis.*—The diphtheria bacillus is pathogenic for guinea-pigs, rabbits, chickens, pigeons, small birds, and cats; also in a lesser degree for dogs, goats, cattle, and horses, but hardly at all for rats and mice. In spite of its pathogenic qualities for these animals true diphtheria occurs in them with extreme rarity. I have seen one cat which had typical diphtheria and from which the diphtheria bacilli were isolated and proved virulent. As a rule, supposed diphtheritic inflammations in animals are due to other bacteria which cannot produce the disease in man.

The virulence of diphtheria bacilli from different sources, as measured by their toxin production, may vary enormously. Thus 0.002 c.c. of a forty-hour bouillon culture of one bacillus will kill a guinea-pig, while it would require 1 c.c. of the culture of another bacillus to kill. From well-marked cases in New York, however, the bacilli have as a rule about the same virulence, nor do they lose in virulence to any great extent when they persist in the throat secretions after convalescence. The same marked variation occurs in the amount of toxin produced by different bacilli in their growth in media outside of the body. There are also bacilli which produce no specific toxin whatever and yet appear to have all the other characteristics of virulent bacilli.

*Diphtheria Toxin.*—It is evident that a micro-organism which, when injected subcutaneously, destroys the life of susceptible animals and produces such marked anatomical changes in the internal organs, while it is found only at or near the point of inoculation, must owe its pathogenic power to the formation of a poison which, being absorbed, gives rise to toxemia and death. This poison or *toxin* has been partially isolated by Roux and Yersin, and others, by filtration through porous porcelain from cultures of the living bacilli. It has not yet been successfully analyzed, so that its chemical composition is unknown, but it has many of the properties of protein substances, and can well be designated by the term active protein.

*Non-virulent Diphtheria Bacilli.*—In the very large number of tests for virulence of the bacilli obtained from hundreds of cases of suspected diphtheria which have been carried out during the past years in the laboratories of the Health Department of New York City, in over ninety-five per cent. of cases the bacilli derived from exudates or pseudomembranes and possessing the characteristics of the Löffler bacilli have been found to be virulent, that is, producers of diphtheria toxin; but there are, however, in inflamed throats as well as in healthy throats, either alone or associated with the virulent bacilli, occasionally bacilli, which, though morphologically and in their behavior on culture media identical with the Klebs-Löffler bacillus, are yet producers, at least in artificial culture media and the usual test animals, of no appreciable diphtheria toxin. Between bacilli which produce a great deal of toxin and those which apparently produce none we find all grades of virulence. So far as we know, bacilli which produce no specific toxin have never later been found to develop it.

Virulent bacilli produce and are found not only in pseudomembranous inflammations of the fauces, larynx, and nasal cavities, but also occasionally in

membranous affections of the skin, vagina, rectum, conjunctiva, nose, and ear (simple membranous rhinitis and otitis media). From the severity of an isolated case the virulence of the bacilli cannot be determined. The most virulent bacillus I have ever found was obtained from a mild case of diphtheria simulating tonsillitis. Another case, however, infected by this bacillus proved to be very severe. In localized epidemics the average severity of the cases probably indicates roughly the virulence of the bacillus causing the infection, as here the individual susceptibility of the different persons infected would, in all likelihood, when taken together, be similar to that of other groups; but even in this instance special conditions of climate, food, race, or concurrent infections may influence certain localities. Moreover, the bacteria associated with the diphtheria bacilli, and which are liable to be transmitted with them, may influence the severity of, and the complications arising in the cases.

*Virulent Bacilli in Healthy Throats.*—Fully virulent bacilli have frequently been found in healthy throats of persons who have been brought in direct contact with diphtheria patients or infected clothing without contracting the disease. It is therefore apparent that infection in diphtheria, as in other infectious diseases, requires not only the presence of virulent bacilli, but also a susceptibility to the disease, which may be inherited or acquired. Among the predisposing influences which contribute to the production of diphtheritic infection may be mentioned the breathing of foul air and living in overcrowded and ill-ventilated rooms, poor food, certain diseases, more particularly catarrhal inflammations of the mucous membranes, and depressing conditions generally. Under these conditions an infected mucous membrane may become susceptible to disease. In connection with Beebe (1894) I made an examination of the throats of 330 healthy persons who had not come in contact, so far as known, with diphtheria, and we found virulent bacilli in 8 only, 2 of whom later developed the disease. In 24 of the 330 healthy throats non-virulent bacilli or attenuated forms of the diphtheria bacillus were found. Very similar observations have since been made by others in many widely separated countries.

*The Persistence of Diphtheria Bacilli in the Throat.*—The continued presence of virulent diphtheria bacilli in the throats of patients who have recovered from the disease, and after the disappearance of the exudate, has been repeatedly demonstrated. Beebe and I found that in 304 of 605 consecutive cases the bacilli disappeared within three days after the disappearance of the pseudomembrane; in 176 cases they persisted for seven days, in 64 cases for twelve days, in 36 cases for fifteen days, in 12 cases for three weeks, in 4 cases for four weeks, and in 2 cases for nine weeks. Since then I have met with a case in which they persisted for eight months.

*Mixed Infection in Diphtheria.*—Virulent diphtheria bacilli, however, are not the only bacteria present in human diphtheria. Various cocci, more particularly streptococci, staphylococci, and pneumococci, are almost always found associated with Löffler bacilli in diphtheria, playing an important part in the disease and leading often to serious complications (sepsis and bronchopneumonia). Indeed, the prognosis in a case of diphtheria is now judged to be graver, other things being equal, according to the degree in which other pathogenic bacteria influence the course of the disease. These cases of so-called *mixed infection* in diphtheria have within recent years attracted considerable attention, and have been the subject of a number of animal experiments. Though the results of these investigations so far have been somewhat indefinite, they would seem to indicate that when other bacteria are associated with the diphtheria bacilli they mutually assist one another in their attacks upon the mucous membrane, the streptococcus being particularly active in this respect, often opening the way for the invasion of the Löffler bacillus into the deeper tissues or supplying needed conditions for the development of its toxin. Thus diphtheria is not always a primary, but often a secondary disease, following some other infection, as measles or scarlet fever. In most fatal cases of bronchopneumonia following laryngeal diphtheria we find not only abundant pneumococci or streptococci in the inflamed lung areas, but also in the blood and tissues of the organs. As these septic infections due to the pyogenic cocci are in no way influenced by the diphtheria antitoxin, they frequently are the cause of the fatal termination. Other bacteria cause putrefactive changes in the exudate, producing alterations in color and offensive odors.

*The Presence of Diphtheria Bacilli in the Blood and Organs.*—Although as I have stated, diphtheria is essentially a local disease, whose symptoms are caused by the elaboration of a specific toxin at the point of inoculation, still in severe cases, with much ulceration of the mucous membrane, bacilli occasionally gain access to the blood stream and indirectly to the urine. That this is a very infrequent occurrence and has no bearing on the course of the disease in spite of recently published reports to the contrary has been proven at the Research Laboratory of the New York Department of Health by the examination of many blood cultures, and specimens of urine from diphtheria cases. During the agonal stage of the disease it is true that bacilli may gain entrance to the blood stream and be found post mortem—scattered throughout the body.

*Pseudomembranous Exudative Inflammations due to Bacteria other than the Diphtheria Bacilli.*—The diphtheria bacillus, though the most usual, is not the only microorganism that is capable of producing pseudomembranous inflammations. There are numerous bacteria present almost constantly in the throat secretions which, under certain conditions, can cause local lesions very similar to those in the less marked cases of true diphtheria. The streptococcus and pneumococcus are the two forms most frequently found in these cases, but there are also others which, under suitable conditions, take an active part in producing this form of inflammation. Some of these bacteria are difficult to grow on ordinary culture media. One of those most frequently found is that described by Vincent and which generally bears his name, which together with the spirochetes which accompany it is found in great numbers in cases of so-called Vincent's angina—a now well-recognized affection. These organisms are strict anaerobes growing best in the presence of serum.

These cases show most of the local appearances of true diphtheria: the superficial necrosis of the epithelium, the membrane, and the glandular swellings. The pseudomembranes may persist for from one to two weeks, or even, in exceptional cases, longer. This bacillus and spirochete are apparently frequently present in the normal throat, and are probably only under certain favoring conditions able to produce lesions. Nerve degeneration and paralysis do not follow an attack.

The pseudomembranous angina accompanying scarlet fever, and to a less extent other diseases, may show the presence not of diphtheria bacilli, but only of the pyogenic cocci, especially streptococci, or, more rarely, some varieties of little known bacilli. The deposit covering the inflamed tissue in these nonspecific cases is, it is true, usually but not always, rather an exudate than a true pseudomembrane. The majority of these cases, however, are mild affections, being of importance only in adding to the severity of the disease which they complicate. At times they are of the greatest severity and not infrequently fatal; this is true also when the larynx is involved with secondary invasion of the lungs. The bacteria which occur in *false diphtheria* are streptococci, staphylococci,

diplococci, and sometimes pseudodiphtheria bacilli or bacilli which are morphologically and culturally distinct from the Löffler bacilli. These will be referred to further under their respective organisms.

*The Transmission of Diphtheria.*—The possibility of the transmission of diphtheria from animals to man cannot be disputed, for cats and many animals can be infected, but, so far as I know, there are no authentic cases of such transmission on record. So-called diphtheritic disease in animals and birds is usually due to other microorganisms than the diphtheria bacilli. Diphtheritic infection, in practically all cases, is contracted, directly or indirectly, though there are undoubtedly some cases of diphtheria in which we cannot determine the source of the infection.

Let us consider some of the unusual means by which the bacilli may be communicated. In actual experiment the bacilli have been observed to remain virulent in bits of dried membrane by Löffler for fourteen weeks, by us for seventeen weeks, and by Roux and Yersin for twenty weeks. Dried on silk threads Abel reports that they may sometimes live 172 days, and upon a child's plaything which had been kept in a dark place they lived for five months. The virulent bacilli have been found on soiled bedding or clothing of a diphtheria patient, on drinking-cups, shoes, hair, slate pencils, etc. Beside these sources of infection by which the disease may be indirectly transmitted, virulent bacilli may be directly received from the pseudomembrane, exudate, or discharges of diphtheria patients; from the secretions of the nose and throat of convalescent cases of diphtheria in which the virulent bacilli persist; and from the healthy throats of individuals who acquired the bacilli from being in contact with others having virulent germs on their persons or clothing. In such cases the bacilli may sometimes live and develop for days or weeks in the throat without causing any lesion. When we consider that it is only the severe types of diphtheria that remain isolated during their actual illness, the wonder is not that so many, but that so few, persons contract the disease. It indicates that very frequently virulent bacilli are received into the mouth, and then either find no conditions there suitable for their growth or are swept away by food or drink before they can effect a lodgment.

*Susceptibility to and Immunity against Diphtheria.*—An individual susceptibility, both general and local, to diphtheria, as in all infectious diseases, is necessary for the contraction of this disease. Moreover, the diphtheria poison does not produce the same effect on the mucous membranes of all persons. Age has long been recognized to be an important factor in diphtheria. Children within the first six months of life are but little susceptible, the greatest degree of susceptibility being between the third and the tenth years, while adults are comparatively immune. An inherited susceptibility or "family predisposition" to the disease has also been observed.

Long before the discovery of the Klebs-Löffler bacillus it was a well-known fact that two attacks of diphtheria seldom occurred in the same individual within short periods of time, and none of us would fear to leave a convalescent case in the same room with one still suffering from the disease. To what this natural susceptibility or immunity is due is still only partially understood, but, as the result of animal experiments, it is now known that an artificial immunity against diphtheria can be produced, at least for a considerable length of time, by the development of substances directly antidotal to the diphtheria toxin. By the inoculation of virulent or somewhat attenuated cultures or of diphtheria toxin, Fraenkel, Behring, Wernicke, Aronson, Roux, and since then many others, have succeeded in immunizing animals; but the most important and valuable results are those which have been obtained by Behring, in conjunction with others, who showed that the blood of immune animals contains a substance which neutralizes the diphtheria toxin. The blood serum of persons who have recovered from diphtheria has been found also to possess this protective property, which it acquires about a week after the beginning of the disease, and loses again in a few months or years. Moreover, the blood serum of many individuals who have never had diphtheria often has a slight general antitoxic property.

*Antitoxin Serum.*—The knowledge derived from these remarkable investigations into the protective powers of the blood serum of immunized animals has been employed with the most brilliant results for the prevention and early treatment of diphtheria in man. For the methods employed to obtain diphtheria antitoxic serum see vol. i., page 847.

Pathology.—*Location of Bacilli in the Membrane.**—Diphtheria bacilli are not found growing in the living tissue, or in connection with those degenerative lesions in the epithelium which can be regarded as the primary lesions of the disease. They are found in the necrotic tissue and in the exudation, usually only in the latter. In a very few cases the bacilli occur enclosed in pus and in necrotic epithelial cells and usually appear in clumps and masses. The masses found deep down in the membrane probably do not represent a downward growth in this, but have been covered up by a further formation of membrane on the surface. The diphtheria bacillus shows in its growth an affinity for solid structures, and is found rather on the reticulum than in the spaces between.

Usually other organisms, particularly the pyogenic cocci, are found associated with it, though not intimately. The membrane and necrotic tissue may also be invaded by fungi.

*Membrane Formation.*—This is due to a combination of processes. It seems probable that the first step in its production is degeneration and necrosis of the epithelium, often preceded by active proliferation of the nuclei of the cells by direct division. The cells may either break up into detritus, with fragmentation of the nuclei, or they may become changed into refractive hyaline masses. An inflammatory exudation rich in fibrin factors comes from the tissue below, and fibrin is formed when this comes in contact with the necrotic epithelium. The fibrin in part is formed into a reticulum around exudation cells and degenerated epithelium, in part it combines with the hyaline degenerated cells to form a hyaline membrane. The hyaline membrane is most often formed on those surfaces which are covered with epithelium having several layers of cells. It may be formed by a hyaline degeneration of exudation cells; in this case the spaces in the meshwork are smaller. It is probable that the fibrinous membrane is formed both on the surfaces and in the tissue. The fibrin is first formed around cells which afterward disappear. In the trachea the fibrinous membrane often has a definite structure, The membrane may disintegrate and be broken up into a mass of detritus (the process commences on the surface), or it may be cast off as a whole by being elevated by an exudation beneath. Very thick masses of membrane may be formed by the constant addition of fibrinous exudation. The membrane is never formed primarily on an intact epithelial surface, but it may extend over it. Nothing is to be gained by making an anatomical distinction between a croupous and a diphtheritic membrane. There is nothing specific in the membrane formation in diphtheria.

The membrane formation is accompanied by changes in the tissue beneath, which represent a combination of degeneration and exudation. The connective tissue and blood-vessels undergo a hyaline, fibrinoid degeneration very similar to the degeneration of the

* The section on Pathology is largely a summary of the monograph by Councilman, Mallory, and Pearce (Journal of the Boston Soc. of Med. Sciences, December, 1900).

epithelium. Necrosis may extend deeply into the tissue, but there is little tendency to deep ulceration or abscess formation. The degeneration in the mucous glands of the tissue is so pronounced as to be almost specific. Marked degeneration of the epithelium of the glands may be found without any change in the surrounding tissue. The changes in the blood-vessels, though so pronounced in diphtheria, are not specific. The extent of the necrosis in the primary lesions is greater than is found in the action of any other bacteria.

*Heart.*—Degeneration of the myocardium is one of the most common conditions found in diphtheria. The simplest form of this is fatty degeneration, which is found in the majority of all cases. This varies in extent, at times affecting the myocardium generally, at other times occurring in foci. The fatty degeneration accompanies and seems to precede the more advanced forms of degeneration which lead to the complete destruction of the muscle. In this there is destruction of the sarcous elements, which become swollen, broken up, and converted into hyaline masses. Simple fatty degeneration is found in the severe cases of short duration, the more extensive degenerations in the more prolonged cases. The degenerations may be so extensive as to account fully for the impairment of the heart action. No bacteria are found in connection with the degeneration, but like most of the lesions of the disease it is due to the influences of the toxic substances in the blood.

Acute interstitial lesions of two sorts are found. In one there are focal collections of plasma and lymphoid cells in the tissue, which may be accompanied by degeneration of the myocardium, but are not dependent upon it. In the other condition the interstitial change consists of a proliferation of the cells of the tissue and is secondary to the degeneration of the muscle.

Thrombosis is not an uncommon condition and is due to primary necrosis of the endocardium. Lesions of the vessels of the heart play but little part; the only lesion of interest is proliferation of the intima, the same lesion which is frequently found in the vessels in other organs.

*Lungs.*—There is no organ in the body in which lesions accompanying diphtheritic infection are so generally found or so serious as in the lung. In very many cases they are so extensive that death may be regarded as due rather to the condition of the lungs than to the throat affection. Extensive lesions are frequently found on microscopical examination even when the lungs presented little or no change to the naked eye. It seems probable that the frequency of these lesions may be due to the fact that most or all of our cases were treated with antitoxin, and that those in which the lung complications were not present, or at least not severe, recovered.

The most common lesion is bronchopneumonia. The term implies both the manner in which infection takes place and the relation of the foci to the bronchi. The process begins as an infection of the atria and from here extends. It may be limited to single acini, to lobules, or to groups of lobules. There is but little lateral extension of the infection through the walls of the alveoli or the bronchi into the surrounding air spaces. Acute inflammation of the larger bronchi usually accompanies the bronchopneumonia, but is not constant. Atelectasis varying in extent from one to several lobules, or even confined to a few air spaces, is very commonly present. The same is true of emphysema. True acute lobar pneumonia was never found. The cases resembling this were found on closer examination to be cases of extensive confluent bronchopneumonia. General edema of the lung comparable to the circulatory edema of adults was never found, although inflammatory edema was common. The character of the exudation varies greatly. It may be fibrinous, hemorrhagic, serous, or almost entirely cellular. The cells in the exudation are partly leucocytes, partly cells derived from proliferation of the lining epithelium. Lymphoid and plasma cells also are found in the exudation. Cellular infiltration of the interstitial tissue and productive changes in it are common, both in connection with the acute exudative lesions and apart from them. In some cases organization of the exudation and the formation of connective tissue within the air spaces were found. Proliferation of the lining epithelium of the air spaces is frequent, and is always more pronounced in the vicinity of the pleura and the connective-tissue septa.

Thrombi are occasionally found in the larger vessels. Dilatation of the lymphatics is very common. They may contain coagulated albumin, fibrin, or cells. They are often found packed with lymphoid and plasma cells, and large cells similar to the large cells in the air spaces.

Councilmen, Mallory and Pierce state that nothing in their experience has shown so well how little the character of a pathological process is influenced by the character of the microorganism as has the examination of the lungs in their investigation. Pneumococci, streptococci, and diphtheria bacilli have been found in connection with serous, purulent, fibrinous, and hemorrhagic exudations, necrosis, and abscess formation. Contrary to the results obtained from cultures, the pneumococcus must be considered the principal agent in producing the lung infection. The diphtheria bacilli are frequently found and may be the cause of bronchitis with membrane formation, of purulent exudation, of bronchopneumonia, necrosis, and abscess. They are often found in the lung in much greater numbers than in any other situation, and there may be but little change in the tissue around them.

*Spleen.*—Lesions of the spleen play but a slight part in the pathological anatomy of diphtheria. The spleen macroscopically does not differ from the normal, except that the lymph nodules usually are more prominent.

*Intestines.*—The lesions of the small and large intestine in diphtheria in man are relatively unimportant. They consist of hyperplasia of the lymphoid apparatus and the same other changes found in the lymph nodules elsewhere. There is nothing in the character of the lesions to indicate the elimination of the toxins by the alimentary canal.

*Liver.*—The lesions produced in the liver in diphtheria are not characteristic, and do not differ from those found in other acute infectious diseases. The most common lesions are a general degeneration of the liver cells, and necroses which are chiefly found in the centers of the lobules.

*Kidney.*—Lesions of the kidney varying from simple degeneration to the more serious conditions of acute nephritis are found in all fatal cases of diphtheria. Some of the lesions are somewhat more common in the mixed infections of diphtheria combined with scarlet fever than in pure diphtheria. The more severe forms of degeneration are found in those cases of diphtheria of great intensity which are fatal shortly after the onset.

The interstitial and glomerular lesions are more common in older children and in cases of longer duration of the disease, though these conditions usually are combined. There is no type of lesion peculiar to diphtheria. The lesions in the kidneys are not due to the presence of bacteria in the blood, but to the action of injurious substances in solution in the blood.

*Nervous System.*—All of the nerves in the twenty-eight cases examined by Councilman showed various degrees of fatty degeneration, from slight to extreme. The degeneration seems almost invariably to begin in the myelin sheath.

As a rule the change in the myelin which causes it to stain with osmic acid in the Marchi method begins at some point close to the axis cylinder and gradually

spreads around and along it. The myelin breaks up into granules, droplets, and very irregular bizarre figures of which the peripheries usually are more refractive than the centers and often doubly contoured. As a rule the centers of the masses stain more deeply than the peripheries, but sometimes small black globules with pale centers appear.

The change in the axis cylinder seems to consist chiefly of swelling which is often irregular, so that the axis cylinder presents a beaded appearance. As it swells it stains very faintly, so that it is often difficult and sometimes impossible to make it out. When the myelin sheaths have undergone marked fatty degeneration, the axis cylinders usually cannot be distinguished. Whether they have simply swelled up and disappeared, or have undergone fatty degeneration, is difficult to determine; but in no axis cylinder which could be positively demonstrated was there any evidence of fatty degeneration.

Examination of the cerebrum five times, cerebellum twice, pons three times, medulla four times, and cord seven times, showed everywhere a slight to marked diffuse fatty degeneration of the white substance. The same change was present in the anterior and posterior nerve roots.

The results of the investigation of the nervous system may be summed up as follows: There occurs in certain cases of diphtheria a slight to marked diffuse fatty degeneration of the nerve fibers of the central nervous system and of its peripheral extensions.

Symptoms.—*Pharyngeal Diphtheria.*—Mild Cases: Those in which the local lesions are moderate in degree and in which the constitutional symptoms are not serious. They may be divided into two classes. In the first the onset is sudden; the temperature rises possibly to 103° F. in the first twelve hours and then rapidly falls, so as to reach the normal one or two days later. With the rise of the temperature the throat symptoms develop. The mucous membranes appear hyperemic and congested, and after a few hours more or less extensive patches appear on the swollen tonsils soft palate, pharynx, or uvula. The local symptoms increase for twenty-four hours and then remain stationary. With the rise in temperature and the local signs of inflammation there are rapid pulse, loss of appetite, and some prostration. At the end of forty-eight hours the constitutional symptoms abate. The temperature is rarely above 101° F. The pulse may still be rapid, but is regular and of good force. The local inflammation subsides in from three to seven days, and the patient is fairly well except for a slight anemia. Even in these mild cases feebleness of pulse and heart beat may develop and danger of heart failure be present.

In the second class the throat inflammation develops slowly. There is a little pain on swallowing. The glands at the angle of the jaw are usually a little swollen and the throat feels sore. Inspection will show slightly swollen tonsils, with follicular deposits of exudate or small patches of pseudomembrane. The temperature is not elevated more than one or two degrees or it may be normal. Except for slight loss of appetite, restless sleep, and slight prostration the symptoms are mainly those of a subacute throat inflammation. The exudate may be strongly adherent, so that it can be removed by force only, or it may be loosely attached. The diphtheria deposit remains for from two to seven days, and then recovery is established. A moderate amount of anemia persists for some weeks. Some cases in either of these two types may, instead of recovering, suddenly begin to extend and develop into the most severe type. Even in these mild cases slight paralysis may occur as late as three weeks after apparent recovery.

Severe Cases: Here, again, two extreme types of invasion are noted: the local and constitutional symptoms may slowly develop, or they may become fully developed within the first twenty-four to forty-eight hours, either with or without high temperatures. In exceptional cases a chill is the first symptom noticed.

The mind is usually clear, although in the worst cases mild delirium or stupor may develop. The mucous membrane of the pharynx and tonsils is reddened and swollen. The uvula may be edematous, elongated, and greatly swollen. Portions or all of the mucous membrane of the tonsils, the pharynx, and the soft palate are covered with more or less thick and fibrinous pseudomembrane of a grayish color. The glands of the neck and their adjacent tissues may be slightly or markedly swollen. If the nasal cavities are involved, the breathing and voice are affected. From the nose flows a discharge which may be of an intensly irritant character and is sometimes blood stained. The nasal obstruction may be partial, in which case the irrigating fluid passes easily, or it may be total, so that it is possible to force fluid through the nose only under high pressure.

After from forty-eight to seventy-two hours the fever, if present, commonly subsides. In favorable cases the pulse becomes less frequent, and remains of fair force and regularity. The appetite improves and the intellect remains clear. After forty-eight hours the local symptoms remain stationary up to the fifth day, and then the swelling subsides; the membrane begins to loosen at the edges, and soon peels off, leaving a superficially ulcerated surface, or it may more gradually melt away. The glands of the neck decrease in size, and the patient is convalescent and certain to recover unless dangerous paralysis develops.

In other cases the course of the disease is unfavorable. The temperature may fall nearly to the normal, but the pulse becomes more rapid, feeble, and irregular, or it may in certain toxic cases suddenly for a time become very slow—forty to fifty to the minute. Before death the heart's action usually becomes more irregular and rapid. Other patients grow apathetic. The urine is apt to be scanty and contain albumin and casts. These patients may suddenly develop uremic convulsions and die, or may gradually waste away. Some develop a persistent nausea and vomit all food. Others suffer from paralysis of deglutition and of the muscles of respiration. Still others seem to be recovering from the diphtheria when the symptoms and physical signs of pneumonia develop. The temperature then rises to 103° or 104° or even 106° F.

In other cases the false membrane does not limit itself to the pharynx but spreads to the larynx. These patient then have, in addition, the special symptoms due to obstruction to the breathing. Finally, there is a group of cases that seem to be fatal as if from gradual systemic poisoning by toxin. The patients lose weight, become pale and anemic, have no appetite, the tongue is dry and coated, and they gradually sink away.

Malignant Cases: There are certain cases of diphtheria, both in children and in adults, which run an especially malignant course. Within twenty-four hours the tonsils, palate, and lateral portions of the pharynx are covered with thick membrane and are enormously swollen, the breath is sweetish, the saliva dribbles from the mouth, the glands of the neck and their surrounding tissues are greatly swollen. The temperature is frequently but slightly elevated or it may be subnormal. The heart's action is rapid and feeble or it may be very slow and irregular. Danger of heart failure is always present. The intellect, at first clear, becomes cloudy. Within from three to five days the most robust die.

Another class of malignant cases includes the so-called septic cases. The amount of local swelling and exudate on the tonsils and palate may not be very extensive, but it is of a dirty, gangrenous appearance. If the nostrils are invaded, there is a bad-smelling, thin discharge.

The temperature runs a high, irregular course, from

103° to 106° F. The tongue is dry and coated and the appetite is poor. The glands of the neck are moderately or greatly swollen. The extremities are cool, the pulse is rapid and feeble. Pneumonia or suppuration of the middle ear frequently develops. With an irregular high temperature the children become more and more apathetic until death usually supervenes.

*Laryngeal Diphtheria.*—The symptoms in laryngeal diphtheria differ somewhat according as to whether the process is a primary one or is an extension of a pharyngeal diphtheria to the larynx. In the latter case laryngeal symptoms are added to those already present.

In laryngeal diphtheria the symptoms are those due both to the absorption of the poison of diphtheria and to the mechanical obstruction of the larynx. The obstruction occurs more quickly in children than in adults.

The symptoms may develop slowly; the child complains of a sore throat, of a little hoarseness, has loss of appetite and slight fever. There may be a dry, hard cough. In some, within from twelve to twenty-four hours the hoarseness becomes marked, the breathing is somewhat obstructed, the temperature reaches 100° to 103° F., and the child is restless. Soon, unless relief is given or the process subsides, the symptoms of laryngeal obstruction are fully developed. The respiration is noisy; inspiration and expiration are labored and prolonged. Cyanosis is developed, and there is marked recession of the soft parts of the chest in the epigastric and jugular regions. The accessory muscles of respiration are called into action and the chest is held expanded. In spite of every exertion inspiration and expiration are insufficient.

At short intervals the child will sink back as if exhausted, the breathing is feebler, and for a moment or two the child dozes, only to awaken again to struggle for air. It throws itself about the bed, lies first on one side, then on the other. Until cyanosis is marked the intellect may be clear. Frequent desire to urinate is manifested, which adds to the distress of the child. As the obstruction increases attacks of almost complete suffocation take place; the child struggles violently for air, sitting up and using all its powers. After a time respiration may become freer, and the child sinks back only to have renewed spasms later. Sooner or later it becomes exhausted; the breathing becomes more and more feeble; the extremities are cold and the skin is of cadaveric hue. Death follows from an attack of suffocation or slowly by asthenia. The duration of life in fatal cases is usually from two to seven days when operative relief is not given.

In purely laryngeal cases, when operative relief is not given and death results early, the temperature frequently remains but little elevated, although in a few it may reach 103°–104° F. If, on the other hand, the lungs are involved, the temperature is, as a rule, elevated to 102° or 104°, or exceptionally to 106° F.

After intubation or tracheotomy the temperature frequently rises, in the more severe cases, within twelve hours to 102°–104° F. When operative relief is attained the breathing becomes natural, mucus and shreds of membrane are coughed out, and the child sinks back to sleep. In a portion of the cases the relief is permanent, and the patient progresses uninterruptedly to recovery. In others the symptoms of obstruction again appear, while in still others a secondary pneumonia develops to delay convalescence or cause death.

*Nasal Diphtheria.*—Of this there are two general types, one subacute and seen most often in older children and producing few or no constitutional symptoms. The lesion is usually confined to the anterior nares on one or both sides. There is a purulent, mucopurulent, and blood-stained discharge. The upper lip and margins of the nose are excoriated. The nature of these cases is frequently not recognized until cultures have been made. The patients are a grave source of danger to those about them and there is always a possibility of extension of the process to the posterior nares, pharynx, and larynx.

The second type is usually one of great severity and occurs most often in infants and young children, frequently as a complication of one of the exanthemata —scarlet fever or measles. Not only the anterior nares but the nasopharynx is involved. This process may be an extension of a pharyngeal diphtheria or the pharynx may be free. There is very marked toxemia with rapid pulse and high temperature with profuse mucopurulent and bloody discharge and great nasal obstruction. The patients not infrequently die from toxemia or of a complicating bronchopneumonia often preceded by laryngeal involvement.

*Conjunctival Diphtheria.*—This not very common form of diphtheria may be caused by the transference of organisms from the throat and nose of the patient but quite as often it is the only apparent focus of the disease. The conjunctiva presents one of the changes described as taking place on the mucous membrane of the pharynx; there may be a thick white membrane on one or both lids or the former may be a dirty yellow color (mixed infection) or again there may be only evidence of a more or less severe catarrhal conjunctivitis from which cultures show the presence of diphtheria bacilli. The lids are swollen, stiffened and glued together. When separated there exudes a serous, seropurulent, or even blood-stained fluid. There are local pain and photophobia. The cheeks are apt to be excoriated from the discharge. Constitutional symptoms are but little marked. The disease has to be differentiated most often from a gonorrheal infection.

*Other Locations of Diphtheria Infection.*—In chronic otorrhea, especially in institutions for children, diphtheria bacilli are not infrequently found in the discharge. How much they have to do with the symptoms is difficult to determine. At other times, however, a distinct membrane may be made out in the auditory canal.

Mastoid wounds from operation as also other surgical and accidental wounds, the female genitals and the anal region, especially of young children, are occasionally infected with diphtheria. In all of the above more unusual locations of infection virulence tests are necessary for a positive diagnosis in cases which are not characteristically developed, as the nonvirulent varieties of bacilli are frequently present in these locations.

*General Condition.*—There are a moderate number of cases having very limited patches of pseudomembrane in which on appreciable symptoms of constitutional poisoning show themselves. They are mostly discovered because of their association with more marked cases. In even mild cases the patients show loss of appetite and of the desire for work or play. They become more or less pale and anemic. The more grave cases soon exhibit severe constitutional effects. The patients have marked prostration, are restless or apathetic, or both by turns. If they live long enough, they become emaciated. The sleep is uneasy. In septic cases mild delirium or stupor may develop. These patients give the impression of being very dangerously ill.

*Temperature.*—The cases differ greatly. Many, both mild and severe, begin with a temperature of from 102° to 104° F. In the great majority the fever subsides, and even in the most severe uncomplicated cases the temperature is apt to range from 98° to 101° after the first forty-eight hours. Some, severe from the start, have a normal or even subnormal temperature.

A certain proportion of septic cases, and all having a complicating pneumonia, develop a high temperature. Other complications, such as otitis or the development of an abscess, will cause elevation of temperature.

A rise of temperature to 103°–104° F., in a case of

laryngeal diphtheria, indicates usually a beginning bronchitis or pneumonia.

*Nervous System.*—In the mild cases, except for a certain amount of apathy, no symptoms are present; in the more severe, there may be also observed the general symptoms of mild delirium, restlessness, and rarely convulsions; also apathy and stupor in the severest cases.

*Circulatory Apparatus.*—In mild cases the pulse is frequent, and perhaps slightly irregular. In bad cases it may be very frequent, 120 to 160, and weak. The force of the heart apex beat is diminished and the sounds are indistinct. After the third or fourth day the rapid pulse may suddenly become markedly slowed. From 120 it may fall as low as from 45 to 50. It is irregular and varies in force. This is an extremely grave symptom. After from twenty-four to forty-eight hours, if the patient lives, the pulse is apt again to become rapid and feeble, and so remain until death. After the first days there is present the danger of sudden heart failure. The pulse may become weak or rapid or more rarely slow while the extremities become cold and there supervene in a few hours all the signs of collapse.

*Digestive System.*—In the mildest cases there is little digestive disturbance, but in those of any severity loss of appetite is noted. In the worst toxic cases no food at all may be retained. The bowels are not, as a rule, affected.

*The Kidneys.*—In the mildest cases, usually, no albumin is found in the urine, but exceptionally, after the third or fourth day, it may appear. In the more severe cases casts, kidney detritus, and large quantities of albumin are usually present. In the worst cases partial or total suppression of urine is apt to occur. These may later develop uremic symptoms. Dropsy is not apt to occur and the prognosis is better than in nephritis following scarlet fever.

*Lymph Glands.*—The lymphatic glands in the neck are usually somewhat enlarged. In the more septic cases they may become enormously swollen. Suppuration is rather infrequent.

*Skin.*—A small percentage of cases develop a general erythema, which may resemble scarlet fever or measles, although at such times there always arises the question whether the eruption is not due to a complicating scarlet fever or measles. An urticaria may also appear. In severe and septic cases hemorrhages occur in the skin as well as in the mucous membranes.

*Joints.*—The joints, except in septic cases, are very seldom affected in diphtheria.

Complications.—*Pneumonia.*—The most feared complication of laryngeal diphtheria is bronchopneumonia. In pharyngeal diphtheria it occurs but seldom. It may develop within twenty-four hours or it may not occur till convalescence is established. In these a little fever remains, and the lungs give the signs of a moderate bronchitis. The temperature then slowly or quickly rises and the respirations become more rapid. Physical examination shows beginning bronchopneumonia, perhaps in one or both lower lobes behind, or, again, in disseminated areas throughout both lungs. In these cases the pneumonia is apt to run a subacute but progressive course. After from one to three weeks the child succumbs to exhaustion.

*Heart Failure.*—From the beginning of the separation of the membrane until well into the fifth week all severe cases are in danger of heart failure. When this symptom is threatening, the patient is pale and the pulse is small and irregular; it is usually rapid and weak or very slow and irregular, forty to fifty. The extremities are cold. The mind remains clear and anxious. The attack may pass off or the pulse may be lost; the patient loses consciousness and death comes gradually. Others, apparently well, suddenly become unconscious, and die almost instantaneously of heart failure.

*Paralysis.*—This is one of the most characteristic symptoms of diphtheria. Frequently with the final separation of the membrane, but also often after the lapse of weeks, paralysis develops in the muscles of the soft palate, less frequently in those of deglutition, of the eye, of the respiratory organs, or finally of groups of muscles throughout the body. When the palate is affected speech is nasal and fluids regurgitate into the nostrils. When the muscles of accommodation are affected, the child cannot read and the pupils do not react. When the voluntary muscles in general are affected the patient may be completely helpless. As a rule, complete recovery takes place within from three to eight weeks, but in the worst cases marked atrophy occurs and months elapse before recovery takes place. When the pneumogastric nerve is involved there is constant vomiting of food and drink. The pulse is very rapid, irregular, or abnormally slow. The patients are extremely weak, the pallor of the face is marked. The slightest movement may result in sudden death. In other cases a fatal pneumonia takes place.

*Relapses.*—In a small number of cases, after partial or complete disappearance of the membrane, a slight recurrence results. With the exudate's appearance the temperature may rise and the glands of the neck become swollen. As a rule, the lesions clear up in a few days. The lymphatic glands may remain slightly enlarged for weeks or months. The only cases in which a relapse is serious are the laryngeal ones. A relapse may occur as late as during the fourth week.

Diagnosis.—In deciding whether a doubtful case is one of diphtheria or not it is necessary to take into account whether the patient has been exposed to diphtheria, to scarlet fever, or to other infectious diseases.

If in any case exposure to diphtheria is known to have occurred, even a slightly suspicious sore throat must be regarded as probably a mild diphtheria. If, on the other hand, no cases of diphtheria have been known to exist in the neighborhood, even cases of a more suspicious nature would probably not be diphtheria.

In judging from the appearance and symptoms of a case one must first acknowledge that there are certain mild exudative inflammations of the throat belonging both to diphtheria and to pseudodiphtheria which appear exactly alike, and have similar symptoms and similar duration. It is not meant to imply that a case is one of true diphtheria simply because the diphtheria bacilli are present, but rather that the doubtful cases not only have the bacilli present in the exudate, but are capable of giving true characteristic diphtheria to others, or later developing it themselves; and that those in whose throats no diphtheria bacilli exist can under no conditions give true characteristic diphtheria to others or develop it themselves. It is true, as a rule, that cases presenting the appearance of ordinary follicular tonsillitis in adults are not diphtheria, and yet it is also true that now and then a case having this appearance is one of diphtheria, and almost every physician has seen such cases from time to time in households infected with diphtheria. On the other hand, in small children mild diphtheria very frequently occurs with the semblance of ordinary follicular tonsillitis, and in large cities where diphtheria is prevalent all such cases must be regarded as more or less suspicious.

*Appearances Characteristic of Diphtheria.*—The presence of irregular-shaped patches of adherent grayish or yellowish-gray pseudomembrane on some other portions than the tonsils is, as a rule, an indication of the lesions due to the diphtheria bacilli. Restricted to the tonsils alone their presence is less certain.

Occasionally, in scarlatinal angina or in severe phlegmonous sore throats, patches of exudate may appear on the uvula or borders of the faucial pillars, and still the case may not be due to the diphtheria bacilli; these are, however, exceptional. Thick, grayish pseudomembranes which cover large portions of the tonsils, soft palate, and nostrils are almost invariably the lesions produced by diphtheria bacilli.

The very great majority of cases of pseudomembranous or exudative laryngitis, in the coast cities at least, whether an exudate is present in the pharynx or not, are due to the diphtheria bacilli. Cases in which no exudate is apparent and those in which the laryngeal obstruction is sudden and the spasmodic element is marked, are, however, frequently due to the activity of other bacteria. Nearly all membranous affections of the nose are true diphtheria. When the membrane is limited to the nose the symptoms are, as a rule, very slight; but when the nasopharynx is involved the symptoms are usually grave. Usually a small area of inflammation indicates a slight or moderate severity and an extensive area a severe infection.

Most cases of pseudomembranes and exudates entirely confined to portions of the tonsils in adults are not due to the diphtheria bacilli, although a few cases presenting these symptoms are. The more complete the involvement of the tonsils the more apt the case is to be due to them. Cases presenting the appearances found in scarlet fever, in which a thin, grayish membrane lines the borders of the uvula and faucial pillars, are rarely diphtheritic. As a rule, pseudomembranous inflammations complicating scarlet fever, syphilis, and other infectious diseases are due to the activity of the pathogenic cocci and other bacteria induced by the inflamed condition of the mucous membranes due to the scarlatinal or other poison. But from time to time such cases, if they have been exposed to diphtheria, may be complicated by it, and in some epidemics mixed infection is common.

*The Exudate due to the Diphtheria Bacilli Contrasted with that due to Other Bacteria.*—As a rule, the exudate in diphtheria is firmly incorporated with the underlying mucous membrane, and cannot—except perhaps during convalescence—be removed without leaving a bleeding surface. The tissues surrounding the exudate are more or less inflamed and swollen. Where other bacteria produce the irritant the exudate, except in the cases due to the bacillus described by Vincent, is usually loosely attached, collected in small masses, and easily removable. Exceptions, however, occur in both these diseases, so that in true diphtheria the exudate may be easily removed, and in lesions due to other bacteria the exudate may be firmly adherent. It is also to be noted that certain cases of diphtheria, especially those with a necrotic membrane, may show large numbers of the anaerobic organisms previously described.

*Paralysis.*—Paralysis following a pseudomembranous inflammation is an almost positive indication that the case was one of diphtheria, although slight paralysis has followed in a very few cases in which careful cultures revealed no diphtheria bacilli. These, if not true diphtheria, must be considered very exceptional cases.

*Bacteriological Diagnosis.*—From the above it is apparent that fully developed characteristic cases of diphtheria are readily diagnosticated, but that many of the less marked, or at an early period undeveloped, cases are difficult to differentiate the one from the other. In these cases cultures are of the utmost value, since they enable us to isolate those in which the bacilli are found, and to give preventive injections of antitoxin to both the sick and those in contact with them, if this has not already been done. As a rule, cultures do not give us as much information as to the gravity of the case as do the clinical appearances, for by the end of from twenty-four to forty-eight hours the extent of the disease is usually easy of determination. The reported absence of bacilli in a culture must be given weight in proportion to the care with which the culture was made, the suitableness of the media, and the knowledge and experience of the one who examined it.

Diphtheria does not occur without the presence of the diphtheria bacilli; but there have been many cases of diphtheria in which for one or another reason no bacilli were found in the cultures by the examiner. This is frequently the case in purely laryngeal diphtheria. In many of these cases later cultures revealed them. In a convalescent case the absence of bacilli in any one culture indicates that there are certainly not many bacilli left in the throat. Only repeated cultures made from both nose and throat can prove their total absence.

Prognosis.—Diphtheria is one of the most difficult of diseases in which to make a prognosis. A case which in the first twenty-four hours seems mild may steadily increase in extent and severity, if antitoxin is not given, until it ends fatally. A case seemingly convalescent may suddenly develop heart paralysis. Laryngeal diphtheria is especially apt to be complicated by pneumonia.

In the smaller cities epidemics vary greatly in their severity from year to year. In the largest cities, however, there are practically always a number of epidemics going on all the time, and the average severity of the whole city does not vary so much. Age has a very marked influence on mortality.

The special dangers to be feared in diphtheria are the invasion of the larynx, the development of bronchopneumonia, serious paralysis, especially of the heart and respiratory muscles, sepsis, and nephritis.

The following division of the cases of true diphtheria, based on the extent, character, and location of the pseudomembrane or exudate, after sufficient time has elapsed for the development of the local lesions, has seemed to me to be of considerable value in prognosis:

1. Cases in which the pseudomembranes are very extensive, thick, and firmly incorporated with the underlying swollen mucous membrane. In these the constitutional symptoms are marked, the mortality at all ages is large, and the danger of paralysis great.

2. Cases in which the development of the pseudomembranes is largely confined to the larynx and bronchi. This form occurs mostly in young children, is very fatal at all ages, and apt to be complicated by bronchitis or pneumonia.

3. Cases in which the pseudomembrane is moderate in amount, involving the tonsils and irregular portions of the uvula and soft palate. These often have marked constitutional and local symptoms for a few days, but nearly always recover, except in very young children.

4. Cases in which the pseudomembrane or exudate is confined to the tonsils. These resemble those in the third division, but the symptoms are less marked. They all recover unless complications exist.

5. Cases in which very little or no exudate is ever present, the mucous membrane being simply slightly swollen and hyperemic. These have usually slight symptoms and recover, but are important to diagnosticate, as they may infect others.

6. Cases of pseudomembranes confined throughout their course to the anterior nares. These occur chiefly in young children. The constitutional symptoms are slight, and all so far recorded have recovered. These cases are seldom met with. When the posterior nares are involved the case is frequently one of great gravity.

7. Exudates or pseudomembranes confined to the eyelids, abraded skin, rectal and vaginal mucous membranes. The cases confined to the first two locations, as a rule, present few constitutional symptoms if the throat is unaffected. When the rectum and vagina are attacked, the severity of the symptoms will depend on the extent of the lesions.

TREATMENT.—*Prophylaxis.*—The patient ill with diphtheria is to be isolated, so far as circumstances permit. Wherever possible a separate room should be provided. Those who care for the sick should wear a special outer garment. Before leaving the room this gown should be removed and the hands carefully washed and rinsed with an antiseptic solution.

The patient should, when old enough, expectorate into some receptacle containing a disinfectant. Everything soiled by the mouth discharges should be disinfected by soaking in some disinfectant solution, by boiling, or by burning. The throat secretions are probably dangerous until at least three weeks after the beginning of the attack and possibly for longer periods.

Wherever possible the probable disappearance of the diphtheria bacilli should be established by the bacteriological examination of cultures. At the conclusion of the illness it is well to disinfect the surfaces of the bedding, carpets, walls, furniture, and hangings in the patient's room by means of formaldehyde gas. It is not necessary to remove the carpets as it is improbable that any live bacilli are present in the parts inaccessible to the gas.

The disposal of the healthy members of an infected family is a matter of great importance. They frequently have already become infected before the first case is diagnosticated, and, if sent away, they may carry the disease to the children of the families which they visit. It is wise, therefore, to keep them at home if they have been exposed to the one taken sick. All those who have been exposed or expect to be exposed to the contagion should receive a moderate injection of antitoxin as a preventive, 500 to 1,000 units according to age. As a prophylactic it is well to gargle the throat frequently and cleanse the nostrils with some mild cleansing solution, such as Dobell's or a weak disinfectant, such as 1 to 10,000 aqueous solution of bichloride of mercury. An immunization dose of antitoxin, together with the frequent cleansing of the throat, will practically insure immunity from diphtheria for at least two weeks. If the danger still persists a second injection of antitoxin is given.

*Local Treatment.*—If one could destroy all the diphtheria bacilli in the parts infected by local disinfection, the disease might, theoretically at least, be at once aborted and its extension to distant parts prevented.

Many clinicians of great experience in the treatment of diphtheria have advised various methods to accomplish this desired result, such as the direct application of nitrate of silver or carbolic acid; but personally I believe that their success must always be limited, and for the following reasons: The diphtheria bacilli are not limited to the exact spot where the pseudomembrane has developed. They are present in the throat secretions, bathing all parts of the pharynx and tonsils before even the local lesions are manifest. Lying thus in the crypts and recesses of the parts, they cannot all be reached and killed by such antiseptic fluids as we attempt to apply to them. It is also true that only in the mildest cases are the lesions wholly accessible to local treatment.

Some years ago a series of experiments were carried out under my supervision by Drs. White and Somerset, the resident physicians of the New York Hospital for Contagious Diseases, to test the comparative value of irrigating the nose and throat with simple cleansing solutions and with disinfectants (1 to 4,000 bichloride of mercury and five- to ten-volume solutions of peroxide of hydrogen). After a fairly thorough trial it was very difficult to see more than a trifling advantage in the use of antiseptic solutions.

If we attempt to kill the bacteria in the accessible lesions by caustics or the actual cautery, we are apt to injure the tissues without killing all of the bacteria, thus doing probably more harm than good. I believe, therefore, that we should not use any treatment which will irritate or lacerate the mucous membrane. I believe that no swab should be used in making applications to the mucous membrane unless it is done by the physician or by a trained nurse, and only then with the greatest care. Personally I prefer to trust to irrigation. For the nostrils I prefer a solution of one teaspoonful of salt to one pint of tepid water. For this purpose the child should be restrained by wrapping as shown in the article on *Intubation.* A few drops of the solution should at first be introduced into one nostril, so as to avoid a sense of suffocation, and then a thorough irrigation of both nostrils and nasopharynx with the removal of nasal casts, mucus, and pus. This operation may be repeated to advantage every three or four hours in severe nasopharyngeal diphtheria. When the patient is intubated it is better to avoid, if possible, nasal irrigation. If the solution container be not raised more than two or three feet above the patient's head there is no possibility of forcing infected material into the Eustachian tubes. The pharynx may be irrigated immediately afterward by placing on the tube a large, hard-rubber nozzle instead of the nasal tip.

In older children and adults gargles may be used when the tonsils only are attacked. The solutions are simply held in the throat as far back as possible and then ejected. It is impossible for most persons through gargles to reach more than the tissues anterior to the faucial pillars.

*General Treatment.*—The air in the patient's room should be pure and kept if possible at a temperature of 68°–70° F.

The remedies suggested for the treatment of diphtheria have been numberless, but few of them have proved themselves of value generally. With the exception of the antitoxin none of them are specific. At the New York Hospital for Contagious Diseases mild cases are given an abundance of light diet, milk, broth, eggs, etc. It is now the general custom to do away with various stimulants in the ordinary case of diphtheria, unless the symptoms call for their use. Of those most frequently used may be mentioned strychnine, caffeine, and digitalis for their effect on the heart's action. Opinions differ as to value of alcohol, a few physicians of great experience still recommending large doses of brandy and whiskey in toxic and septic cases, the majority using it not at all or only in moderate amounts. As the patients begin to convalesce they are given some preparation of iron as a tonic if they show much anemia.

The antipyretics are to be avoided, because of their depressant effect, and also because the temperature is, as a rule, not seriously high in diphtheria.

The tincture of the chloride of iron in moderate and frequent doses is thought by many to be of great benefit, both locally and for its tonic effect, though if it causes nausea or vomiting it should be stopped. Jacobi advises up to 3 i. each day for an infant, and for a child three years old twice that amount. Large doses do not appear to have any more beneficial effect than small, and are more apt to cause irritation of the stomach. The internal administration of bichloride of mercury, gr. $\frac{1}{48}$ to $\frac{1}{12}$ daily, in divided doses, has not seemed to me to be of any other than local value, though thought highly of by some. Good observers advocate small to moderate doses of quinine. I myself have had but little experience with its use.

Whenever paralysis of the muscles of deglutition has become sufficiently marked to prevent the swallowing of food, it is necessary to feed through a soft-rubber tube passed through the nose into the pharynx and esophagus. All having serious disease should remain as absolutely quiet as possible and should take their food and evacuate their bowels in a recumbent position. Bronchitis, pneumonia, otitis, nephritis, and other diseases complicating diphtheria are treated as if they were primary diseases.

*Treatment of Laryngeal Diphtheria.*—In the early stage of laryngeal diphtheria, the attacks of suffocation are, in large part, due to spasm of the congested vocal

cords, so that measures to overcome this, while the antitoxin is being absorbed may in a certain number of cases be successful in doing away with the necessity for intubation or tracheotomy. Of these may be mentioned steam.

The inhalation of warm steam is certainly at times of great benefit. To the water may be added equal parts of lime water, or to each pint one or two teaspoonfuls of compound tincture of benzoin. The warm, damp vapor is the chief thing. The steam should be inhaled as warm as possible, and the patient should be protected from the dampness by a covering of oil-muslin, or a thin blanket.

Calomel fumigations formerly so much employed are now seldom used. Emetics are but rarely made use of except in small doses and then for their ability to relax spasm: Ipecac (the syrup or powder in small doses given every hour); Dover's powder in doses of one-tenth to one-half grain at frequent intervals are often of seeming benefit. Sedatives may also be used alone or together with the former. Sodium bromide given in doses of gr. i–v., every two or three hours; morphine hypodermatically in doses of gr. $\frac{1}{20}$ to $\frac{1}{8}$ to a young child may be used to advantage for this purpose. Finally it is most important that every effort be made to insure absence of excitement on the part of the patient and for this reason a mother or the child's own nurse are often more desirable attendants than strangers.

*Intubation and Tracheotomy.*—If in spite of treatment the laryngeal stenosis advances so far that actual obstruction to breathing is marked and increasing, we must resort to intubation or tracheotomy.

By one or the other of the means we overcome the obstruction to the entrance of air through the larynx, and thus prevent suffocation, unless the membrane is too extensive below the end of the tube. We also aid the expulsion of mucus and portions of membrane through the opening formed by the tube. The insertion of the tube does not, of course, limit the extension of the disease or prevent complications. The apparent improvement due to the removal of the obstacle to respiration will therefore only be permanent when the disease itself yields to treatment.

The time at which intubation should be performed is a question of the greatest importance.

The insertion of a tube into the larynx is not wholly a matter of indifference even in trained hands. More or less abrasion of the swollen and inflamed laryngeal mucous membrane may be caused by its insertion, and its presence for several days is very likely to cause a superficial ulceration, either where its lower end impinges on the trachea or where its sides cause pressure.

On the other hand, so soon as the laryngeal stenosis becomes so marked that the person struggles for air, and in spite of the struggle sufficient aeration of the blood does not take place, that condition is a great detriment to the condition of the child long before any actual suffocation is impending.

In spite, then, of the possible injury to the larynx of the insertion and retention of the tube, we should not wait too long and thus allow a greater injury to occur. If, therefore, the stenosis steadily increases and the retraction of the epigastric and jugular regions becomes decided, and cyanosis is evident, it is better not to wait longer. (See article on *Intubation.*)

*Serum Therapy.*—The employment of diphtheria antitoxin has passed the experimental stage and its use is now as firmly established as is that of vaccine as a preventive of smallpox. Its action is to neutralize the diphtheria poison produced by the diphtheria bacillus and thus to render it inert and powerless to do injury. It is most important to realize that both in animals purposely infected with diphtheria and in human beings ill with the disease the beneficial effects of antitoxin are most evident when it is given very early in the disease, before marked tissue degeneration has occurred.

Statistics gathered from all over the world are in accord, that the cases injected on the first day show the least, those on the second somewhat more, and those on the later days the greatest mortality. The chemical nature of antitoxin has already been considered under *Antitoxins* in Vol. I. As the results obtained with the antitoxin treatment have been so much in evidence during the past eighteen years, I will give here only a few figures from Krönlein (Zurich), quoted from the article on diphtheria by Jacobi in the "Twentieth Century Practice of Medicine." These are in accord with my personal observations.

| | Mortality, per cent. |
|---|---|
| Preantitoxin period, total cases. . . . | 39.3 |
| Operative cases. . . . . | 66.1 |
| Antitoxin period, total cases. . . . . | 12.5 |
| Operative cases. . . . . | 36.0 |

When antitoxin is given in sufficient amount shortly after the onset of the first symptoms the mortality is less than four per cent. It is rare for a case of diphtheria thus treated to end fatally unless complicated by pneumonia.

The immediate results which follow an injection of antitoxin in a case of diphtheria differ according to the period of the disease at which it was given and the characteristics of the case. This is due to the fact that while injection of sufficient antitoxin prevents any further effect of the diphtheria toxin, it will not lessen the toxic effects of the poisons produced by the other bacteria nor will it stop the progressive degeneration of cells already so injured that recuperation is impossible.

When antitoxin is administered early in pharyngeal, tonsillar, and nasal diphtheria the results are usually striking; improvement sets in quickly, the temperature after its initial rise drops within from six to twelve hours, the local inflammation abates, and the membranes and exudate loosen in from eighteen to thirty-six hours. The local disease does not spread to adjacent or distant portions of the mucous membranes. Except for slight prostration and anemia the patient is frequently well in from two to three days.

When antitoxin is administered after the full development of the diphtheria the results are much less striking, so that in some we are in doubt as to whether any actual results have been obtained. Undoubtedly many of these cases run a milder course than without antitoxin.

In laryngeal diphtheria it is difficult to be certain of the immediate effects in individual cases. When we examine a case we cannot as a rule tell the amount of larynx, trachea, and lung involved, and so are ignorant of the real severity and extent of the disease.

More patients receiving antitoxin early recover without having needed intubation than formerly, and those needing intubation are on the average able to have the tube removed earlier than before. Upon the bronchitis and bronchopneumonia which have already developed antitoxin has little effect.

*Ill Effects of Antitoxin Serum.*—A considerable percentage of the cases have a slight rise of temperature immediately after an injection. In a very few cases abscesses develop at the seat of the injection. This is a preventable accident.

*Rashes.*—These are peculiar to the serum injections. They are undoubtedly due to the horse serum-globulins and occur just the same whether these are antitoxic or normal. They occur in from five to twenty per cent. of the cases, according to the characteristics of the serum. The eruption may be limited to the point of injection, or may more or less completely cover the whole body. It most often appears as an urticaria, but may very closely resemble scarlet fever or more rarely measles. It usually develops between the seventh and fifteenth days, but may occur as early as on the second day. In some cases all the forms may

be united in one person. Following the scarlatiniform eruption, desquamation may occur. In about one-fifth of the cases having the severer forms of rashes there is a rise in temperature of 2°–4° F. This lasts for from one to three days. In a very small percentage of cases there is accompanying the rash tenderness over the joints of the extremities. These pains last, as a rule, for from one to four days. There have been a few cases reported in which the joint lesions persisted for several weeks. The urticaria and erythema

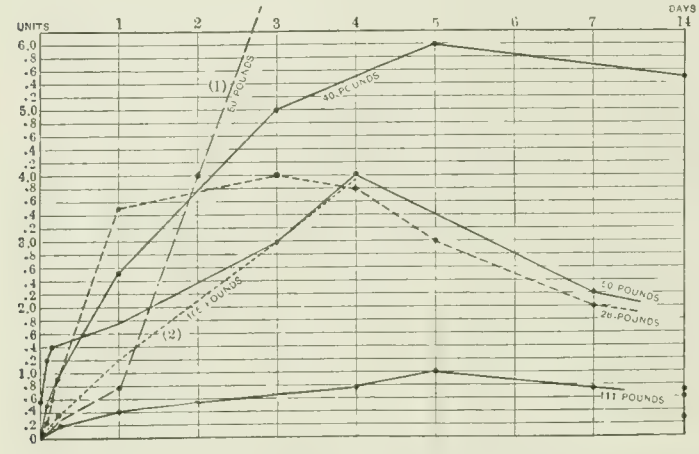


Fig 1714.—Chart Showing the Extent and Rapidity of Absorption of 10,000 Units of Antitoxin Given Subcutaneously. Each line represents the antitoxin content of 1 c.c. of blood at different intervals of time.

which at times accompany the rise in temperature are in certain cases distressing, and in a person already prostrated might not be wholly without danger.

I have seen, in watching over fifteen hundred cases, no serious effects upon the heart, kidney, or nervous system which I attribute to antitoxin, with the possible exception of two cases of scarlatina complicated with diphtheria. In these two there was an almost complete suppression of the urine. This was probably due to the scarlet fever and diphtheria, and not to the antitoxin. The refining of antitoxin which submitted the serum to a temperature of about 60° C. and eliminated fifty per cent. of the protein has lessened the number and also the severity of the rashes.

*Cases of Sudden Death.*—Over 150,000 persons have been injected by the Department of Health physicians since the introduction of antitoxin. Two deaths due to the serum have occurred. Both followed after primary injections.

*Anaphylaxis.*—The danger of giving a second injection has been exaggerated by many. An experience covering over 1,000 cases teaches that except in cases of asthma there is no more danger in giving a second subcutaneous injection than in giving the first. A rash and rise of temperature, when they occur, are apt to appear within twenty-four hours instead of after several days. Intravenous injections should always be given slowly to sensitized persons and serious results will then seldom occur. I am sure that antitoxin should never be withheld either in treatment or immunization because of fear of anaphylactic shock after some future injection.

*Facts Bearing on the Dosage of Antitoxin.*—The amount of antitoxin given is not measured to neutralize the amount of toxin supposed to be present. The average moderate case has not enough uncombined toxin in the blood or tissues to neutralize a unit of antitoxin and the most severe one not enough to neutralize one hundred units. This has been discovered by testing the blood in numerous cases.

The antitoxin to reach the infected tissues and the toxin in the lymph must pass out from the capillaries. This it does very slowly and imperfectly, the fluid passing from the blood-vessels having but about one per cent. of the antitoxic strength of the blood. In severe cases it is necessary to give large amounts so that the blood being lightly antitoxic the tissue fluids may soon become feebly so.

*Absorption of Antitoxin.*—Many believe that the antitoxin injected subcutaneously is absorbed within a few minutes. It is not wholly absorbed for from two to four days. This is shown clearly by the first of the charts, which gives the actual antitoxic strength of the blood from hour to hour and day to day in seven diphtheria cases, each of which had received a single dose of 10,000 units of diphtheria antitoxin subcutaneously. The second chart is an exhibit of four cases of diphtheria in which the same dose of antitoxin was given intravenously. The units noted are the number contained in 1 c.c. of blood.

In the subcutaneous injections it is noticed in every case the antitoxin content of the blood increased rapidly in amount from the first to the twenty-fourth hour and then, as a rule, more slowly for the next twenty-four to forty-eight hours, and that in none of the cases did the antitoxin content of the blood decrease until after the third day.

It is seen that if a single subcutaneous or intramuscular injection is given, the blood during every hour of the first twenty-four hours will contain much more antitoxin than if the same amount is divided and given at intervals of eight or twelve hours.

The antitoxin given intramuscularly is absorbed in about two-thirds of the time required by that given by the subcutaneous method. The antitoxin when given intravenously adds to the blood the whole effect immediately and during the first twenty-four hours averages more than five times as much as in cases in which the same dose is given subcutaneously. The antitoxin content of the blood after an intravenous injection steadily falls after the injection, but not as rapidly as most people believe. It is evident on the chart that on the fourth day about half of the antitoxic strength

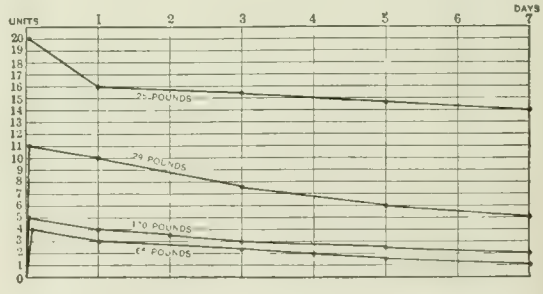


Fig 1715.—Chart of the Antitoxin Content of Human Blood at Intervals after an Intravenous Injection of 10,000 Antitoxic Units.

still remains. It is seen that, as a rule, the smaller the patient the higher the antitoxin content of the blood. If the individuals did not produce any antitoxin themselves and if the quantity of blood was exactly proportional to their weight and the destruction or disappearance of the antitoxin was similar in all cases, the relative strength in the blood in the different cases would be directly proportional to their weight, as it would be simply the question of dilution. These three conditions, however, do not appear uniformly in the

different cases, so that while it is true in a broad sense, there are individual exceptions. This is one reason for giving a large dose. The complete neutralization of the poison which is free in the blood can undoubtedly be accomplished in the space of a few moments by an intravenous injection.

*Single or Multiple Injections.*—The usual method of administering antitoxin is to give an injection every six to twelve hours during the first day and every twelve hours after that time until the symptoms improve. It is difficult after studying the charts to find any reason for the frequent dosage.

As one looks at the charts the conviction becomes strong that after the first twelve hours following an injection all the toxin in the body not so firmly united to the cell substance as to be beyond reach has been neutralized, and that all we have to do further is to keep the blood antitoxin so that any toxin still in the infected area will surely be neutralized. With no further injection the blood remains strongly antitoxic for one week.

The first dose should be sufficient for the case, and any further doses should be given only because one has not judged correctly the amount required in the first dose. There is no harm in giving additional doses even if the first dose is sufficient, but there is great harm in relying on later doses to add to the effect of a small first dose.

We have watched the results at the Willard Parker Hospital in nearly 100 cases of laryngeal diphtheria in which antitoxin was given intravenously in a single dose of 10,000 units and also an equal number in which it was given subcutaneously. The difference was only slightly in favor of the intravenous injections. In a few malignant pharyngeal cases the intravenous injections seemed to give decidedly better results.

In the intubation cases, while the mortality was nearly as high, the general condition of the patient improved more rapidly after the intravenous injections than in the series which received the subcutaneous ones. The presence or absence of pneumonia was usually the deciding factor as to recovery in these cases.

A consideration of the charts shows that it is foolish to consider the effect occurring soon after a second subcutaneous injection administered within the first twenty-four hours of the first injection as due to the former, as it really is due to the further absorption of the antitoxin of the first injection, and only to a limited extent the result of the second and third injections. During the past year only five per cent. of the cases treated at the contagious disease hospital have received more than one dose, and in these it is doubtful if the second injection did any good.

*Dose.*—The dose advised in the very severe toxic cases is 20,000 in adults and 10,000 to 20,000 in children. A repetition of the dose is not necessary. In these cases the antitoxin should be given intravenously, if it is possible. The moderate cases receive a single dose of 10,000 units. This is usually given subcutaneously, although an intravenous injection will produce quicker results. In mild cases 3,000 to 5,000 units suffice. Even smaller doses than these here suggested will produce great good, if they are given early in the disease. For the bronchopneumonia and sepsis complicating some of the worst cases antitoxin is generally of no avail, but I think I am correct in saying that it is the opinion of the visiting physicians at the hospital that moderate doses accomplish nearly as good results as very large ones. The important points to remember are that the antitoxin should be given at the first possible moment and that the first injection should be of sufficient size. Whether subsequent injections are given or not is a matter of little importance, if the first two vitally important things have been carried out.

I wish to thank Dr. Matthias Nicoll, Jr., for his assistance in revising the medical portion of this article.

WILLIAM H. PARK.

**Diplacanthus.**—A synonym for *Hymenolepis*, a genus of tapeworms. *D. nanus*, or *Homenolepis nana*, is the dwarf tapeworm of man. See *Cestoda*.

A. S. P.

**Diplogonoporus.**—A genus of tapeworms, *Dibothriocephalinæ*, with a short scolex, powerful suckers, and two sets of genitalia side by side in each proglottid. *D. grandis* has been observed twice as a human parasite in Japan. See *Cestoda*.

A. S. P.

**Diplopia** (from διπλόος, double, and ὤψ, eye), as a binocular manifestation, is the double vision resulting from the formation of incongruous images of the same object on non-corresponding parts of the retinæ of the two eyes. Strictly speaking, in every act of binocular vision this condition obtains for all objects which are either nearer or more distant than the point of intersection of the visual axes, although, in these cases, the incongruity of the two images ordinarily asserts itself as perception of a difference in distance (stereoscopic vision) rather than as double vision. In viewing a near object against a distant background, the details of the background as seen by either eye singly are in a measure effaced as a result of accommodation for the shorter distance; and in binocular vision the incongruity of the images of the background operates as a further and greater hindrance to their recognition. Hence, in looking far away, as at a landscape viewed from a window screened by thin gauze, we may be unconscious of the presence of the screen, although, by a voluntary exercise of accommodation and convergence, we may see its meshes distinctly, and may then become aware of the fact that the finer details of the landscape are no longer seen clearly depicted, and that its more conspicuous features appear doubled. In fact, we concentrate the attention habitually upon objects at about the distance for which the two eyes are accommodated and for which their axes are converged, and give little or no heed to the less perfectly defined and doubled images of nearer or of more distant objects.

The incongruity of the two retinal images of objects nearer or more distant than the point of intersection of the visual axes, is demonstrated by holding a small object, such as a pencil, in a vertical position at a distance of a foot or two from the face and at about the same distance from a vertical bar of the window sash; if we look with the two eyes at the pencil it will be seen single between two images of the sash bar, and if we look with the two eyes at the sash bar it will be seen single between two images of the pencil. That this seeing of one or the other of the objects doubled is the result of simultaneous visual recognition of incongruous retinal images in the two eyes is shown by the fact that the doubling disappears on closing or covering either eye.

If, directing the eyes upon the nearer object (the pencil) so that the more distant object (the sash bar) is seen doubled, we cover the right eye, we find that we shut off the right-hand image of the more distant object; similarly, covering the left eye, we shut off the left-hand image. The double vision (diplopia) is then, in this case, *homonymous—i.e.* the image to the right is seen by the right eye, and the image to the left by the left eye. If now, directing the eyes upon the more distant object (the sash bar) so that the nearer object (the pencil) is seen doubled, we cover the right eye, we find that we shut off the left-hand image of the pencil, and, covering the left eye, we shut off the right-hand image. The diplopia is, in this case, *heteronymous*, or *crossed*.

Let *D* and *S* (Fig. 1716) represent the right and the left eye, respectively, and suppose both eyes directed upon a small near object at *P*. The retinal images,

*Pd* and *Ps*, will then be formed each at the fovea centralis of its own eye, and the object *P* will be seen single with the two eyes. If now we suppose a second and more distant object at *R*, two images of *R* will be formed, at *Rd* and *Rs* respectively, each to the inner or nasal side of the fovea. The more distant object *R* will then be seen by the right eye in the direction *DR* to the right of *DP*, and by the left eye in the direction *SR* to the left of *SP;* therefore doubled, and the doubling (diplopia) will be *homonymous*.

If we suppose both eyes directed upon the more distant object at *R*, the retinal images, *Rd* and *Rs*, will be formed each at the fovea centralis of its own eye, and *R* will be seen single with the two eyes;

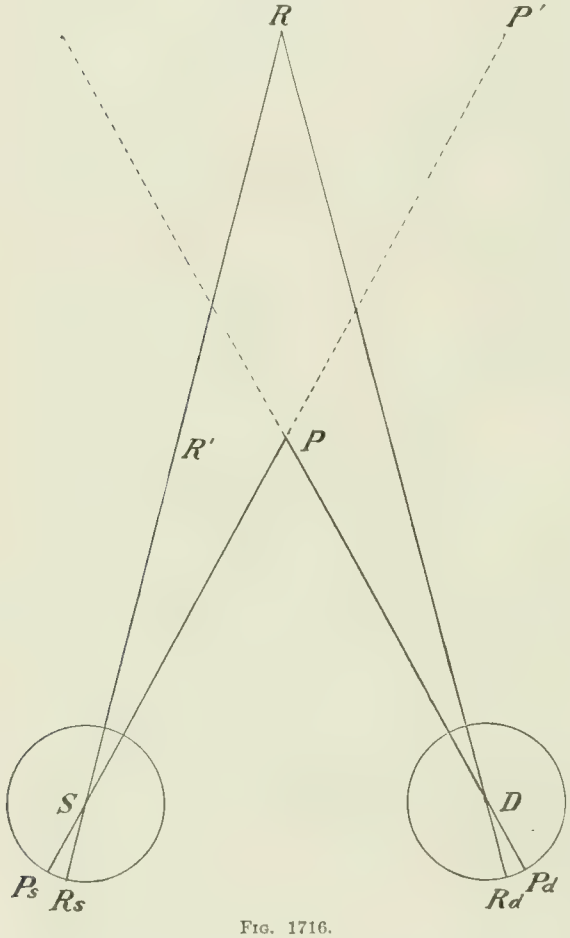


Fig. 1716.

but two images of *P* will be formed, at *Pd* and *Ps* respectively, each to the outer or temporal side of the fovea. The nearer object *P* will then be seen by the right eye in the direction *DP* to the left of *DR*, and by the left eye in the direction *SP* to the right of *DR;* therefore doubled, and the doubling (diplopia) will be *crossed*.

The direction in which an object is seen in binocular vision is that of the point of intersection of the visual axes from a point midway between the eyes. When, however, only one of the eyes is directed upon the object, it is seen in the direction of the axis of that eye, and the image formed on the retina of the fellow eye is projected eccentrically in the visual field, to the side opposite to that to which the eye is diverted. Thus in the case of an eye which deviates inward, the retinal image formed at the inner side of the fovea is projected to the outer side of the object, as seen with the accurately directed eye. A diplopia which is the result of *crossing* of one eye is therefore *homonymous*. Again, when one of the eyes deviates outward, the retinal image formed at the outer side of the fovea is projected to the inner side of the object as seen by the accurately directed eye. A diplopia which is the result of *divergence* of one eye is therefore *crossed*. In the case of a vertical diplopia, the higher position of the second image indicates that the misdirected eye is turned downward, and *vice versa*. So, too, in the case of a diplopia in which the direction of a line drawn through the two images is intermediate between the horizontal and the vertical, the displacement of the second image on this oblique line is in the direction opposite to that in which the misdirected eye is turned.

Referring again to Fig. 1597, suppose the eye *D* directed upon an object at *R*, and the eye *S* upon an object at *P′*, on the line *SP* produced. Two dissimilar images, *Rd* and *Ps*, will then be formed, each at the fovea of its own eye. From the central position of the two retinal images it might be inferred that two dissimilar objects would be seen together, in a confused binocular impression. This is, however, not ordinarily the case. Either the attention is concentrated upon the object *R*, which is seen centrally and distinctly with the eye *D* and eccentrically and therefore less distinctly with the eye *S*, or upon the object *P′*, which is seen centrally and distinctly with the eye *S*, and eccentrically and therefore less distinctly with the eye *D*. In the one case the object *R* is seen homonymously doubled, and the two images of *P′* are ignored; in the other case the object *P′* is seen homonymously doubled, and the two images of *R* are ignored.

Again, suppose the eye *D* directed upon an object at *P*, and the eye *S* upon an object at *R′*, in the direction of *R*. In this case two different retinal images, *Pd* and *Rs*, are formed, each at the fovea of its own eye, but the attention is concentrated either upon the object *P* or upon the object *R′*, one of which is seen heteronymously doubled (crossed diplopia), and the other ignored.

Diplopia may be evoked experimentally by pressing lightly upon one eye through the eyelid; a second image appearing at the side opposite to that to which the axis of the eye is diverted. Diplopia may also be evoked by altering the direction in which the pencils of rays from any object enter one of the eyes, as in looking through a weak prism held in front of one eye. If, while looking at any small object with both eyes, we interpose a weak prism in front of either eye, so that its thin border shall bisect the pupil, the object will be seen single with the two eyes through the uncovered half of the pupil, and doubled through the half of the pupil covered by the prism. On varying the position of the prism, so as to look either past it or through it, objects are seen single or doubled, at will; but when the edge of the prism is turned either toward the nose or toward the temple, the (crossed or homogenous) doubling evoked by looking through it may be overcome by increasing or by relaxing the convergence. When the edge of the prism is turned vertically or obliquely upward or downward, the resultant vertical or oblique doubling either persists or is overcome by a consistent effort attended with irksome muscular strain.

Diplopia, as an anomaly of vision, may be the result of any deviation from normal relative direction of the axes of the two eyes. Such deviation may be the effect of a purely mechanical cause, as when the range of mobility of either eye is limited by a cicatrix of the conjunctiva, by a symblepharon, etc.; or it may be dependent on displacement of one of the eyeballs by an orbital hemorrhage or tumor, or on a fracture of the bony wall of the orbit, impairing the lateral support of the globe or perhaps impeding the action of one or more of the ocular muscles. Diplopia from such causes may be transient, or permanent;

it may be present, in varying degree, in all positions of the eyes, or it may appear only on turning the eyes in some particular direction, and may then be overcome by turning the head.

Faulty coordination of the muscles by whose harmonious action the two eyes are directed upon the same point may be the cause of diplopia which may or may not be recognized as such by the patient, but which, in particular cases, he may be able to overcome by a faulty carriage of the head. Inasmuch as the binocular range of adduction is somewhat increased when the eyes are directed downward, and diminished when they are directed upward, the homonymous diplopia in a case of slight preponderance of the recti interni may be overcome by habitually bowing the head; and, conversely, the crossed diplopia in a case of slight preponderance of the externi may be overcome by habitually elevating the head. In such cases simple or compound prismatic spectacles, with the edges of both prisms turned outward or inward according as the externi or the interni are in need of assistance, may be helpful in reëstablishing binocular vision in the normal position of the head. So, also, a slight deviation of one of the eyes upward or downward may give rise to a vertical diplopia which may be corrected by wearing spectacles of which one of the glasses is a prism with its edge turned upward or downward, as may be indicated; or a pair of prisms may be given, with their edges turned in opposite directions, so as to divide the correction between the two eyes.

As in normal binocular vision both eyes are directed upon the object, with the result that two nearly identical images, falling centrally upon the two retinæ, are fused automatically in a single stereoscopic picture, so in diplopia dependent on faulty relative direction of the two eyes the object is always fixed by one eye; the image falling centrally upon its retina and eccentrically upon the retina of the deviated eye. Of these two images, the central image, in the fixing eye, is recognized as the "true" image and is utilized in seeing the object and estimating its direction; at the same time, the eccentric image, in the deviated eye, is projected in the field of vision as a confusing "false" image. Simultaneous vision with the two eyes becomes then an annoyance rather than a help, and the sufferer learns to suppress the false image, at first by covering or closing the deviated eye and later by ceasing to take cognizance of it.

This psychical suppression of binocular vision is exemplified in early and later stages of strabismus convergens or cross-eye. In the earlier (periodic or intermittent) stage binocular vision is conserved so long as both eyes are directed upon the object, but gives way to vision with a single eye from the instant the fellow eye crosses. In the alternating type of cross-eye the patient is able to fix the object with either eye, but receives no visual impression from the other eye. In confirmed crossing of one eye he sees only with the straight eye, but on covering this may fix accurately with the other eye; the habitually straight eye then becoming crossed.

In typical cross-eye the angle of deviation is conspicuously large, with commensurately large displacement of the retinal image in the crossing eye; the deviation of the eye and the displacement of the image persisting when the eyes are turned in any direction. To suppress the false image it would appear therefore to be necessary to disregard only such comparatively small part of the picture in the deviated eye as is formed on a definite and rather small eccentric area of its retina. That this is what actually occurs in many cases of strabismus is shown by the fact that the suppressed diplopia may often be made manifest by changing the relative position of the images by looking through a prism or prisms placed before one eye or both eyes. So, also, a previously suppressed diplopia not infrequently reasserts itself as a result of the change in the position of the false image following an approximate correction of strabismus by an operation.

The suppression of one of the images in strabismus, although complete under ordinary conditions, may be shown to be often incomplete by varying the conditions under which the object is viewed. Thus, in looking at the flame of a lamp, at a distance of from ten to twenty feet, the light is seen single, with the fixing eye; but on placing a colored glass before one of the eyes it may be possible to recognize two widely separated images of the flame in distinctive colors.

By the use of the "glass-rod" test of Maddox, which consists in looking transversely through a cylindrical glass rod of 4 mm. or 5 mm. diameter held in front of one eye, the flame of a lamp, as seen with this eye, is drawn out into a long bright streak at right angles to the axis of the rod. This linear streak, which is the visual projection of the greatly elongated retinal image of the flame, is often perceived simultaneously with the flame in cases in which prisms or colored glasses, whether used alone or in combination, give a negative result. As improved by the substitution of several smaller parallel rods (which may be of colored glass) for the single rod, or replacing the system of rods by a disk of colored glass crossed by parallel flutings, this test affords a convenient and effective means for the detection and clinical investigation of a latent or a suppressed diplopia.

In paralysis or paresis of one or more of the external muscles of the eyeball dependent on defective innervation, diplopia asserts itself on looking in directions in which the disabled eye lags behind its fellow; the angle of deviation increasing with the extent of the excursion of the accurately directed eye. Thus the retinal image, falling at a varying distance from the fovea and projected in varying positions in the visual field, is less easily suppressed than when (as in strabismus) the angular displacement of the false image is constant. In cases of chronic paralysis the unopposed antagonist of the disabled muscle is apt to become shortened, so that some degree of doubling appears in the more favorable positions of the eyes; but the diplopia remains variable in degree, and may persist indefinitely as a source of visual disturbance.

In diplopia dependent on impaired motility, from whatever cause, it is ordinarily the affected eye that deviates; but it sometimes happens that this is so much the better-seeing eye as to be retained permanently in use, to the exclusion of the eye which is unrestricted in its movements. Hence it is possible to fall into the error of referring a defect in motility to the wrong eye; as, for instance, in a case of vertical diplopia, in which it may be difficult to decide whether one of the eyes is turned a little upward or the other a little downward, or in a case of homonymous or of crossed diplopia, in which it may be a question whether the excessive or insufficient convergence has its seat in one or the other of the eyes, or perhaps in both eyes. From the clinical point of view those shortenings in diagnosis are ordinarily of secondary importance, for the reason that when the deviation is such as to admit of the correction of the diplopia by wearing prismatic spectacles it is generally preferable to divide the correction between the two eyes, and in cases requiring surgical intervention the most perfect results are often obtained by operating on both eyes.

We have thus far considered diplopia as the visual expression of faulty relative direction of the eyes; but it is often the case that the misdirected eye is also rotated about its axis, so that objects seen by it appear both displaced and rotated in a direction contrary to that of the deviation and rotation of the eye. Of the six pairs of muscles which control the movements of the eyes, the recti interni and externi turn the two eyes to the right and to the left, and regulate the convergence of their axes in binocular vision.

The other muscles—the superior and inferior recti and the inferior and superior oblique—acting singly, both change the direction of the eyeballs and rotate them about their axes; but in normal binocular vision the rotating action of a superior rectus, in looking upward, is neutralized by the correlated rotating action of the inferior oblique in the contrary direction, and the rotating action of a inferior rectus, in looking downward, is neutralized by the contrary rotating action of the superior oblique. The combined displacement and rotation of the projected retinal image, in a case of impaired function of one of these four muscles in either eye, is shown by requiring the patient to look at the thin edge of a foot-rule held in a horizontal or vertical position a foot or two from the face; the varying position and direction of the false image, in looking above or below the center of the rule, indicating the ineffective muscle of the misdirected and rotated eye. Diplopia with rotation of the false image is a source of especially annoying and persistent visual disturbance; the rotation cannot be overcome by wearing prismatic spectacles; an operation on the weakened muscle (advancement of its insertion) is, at best, only palliative; and setting back the position of the muscle which is the active cause of the combined deviation and rotation when the eyes are turned in certain directions may only aggravate the trouble by giving rise to new and disturbing limitations of the movements of the eyeball in looking in other directions.

An anomalous form of diplopia is occasionally observed in which a false image, evoked by colored glasses or by the Maddox test, is seen at the side of the object opposite to that at which it should appear in accordance with the law of optical projection. The few instances of this anomaly which have come under the observation of the writer have been in cases of convergent strabismus which had been approximately corrected by operation, but in which inconspicuous residual crossing was revealed in alternate distant fixation. In a case followed for twenty-three years in a boy first seen at the age of six-and-a-half years, the left eye had crossed periodically for about eighteen months, and permanently after whooping cough at the age of four years. The ophthalmoscope showed hypermetropia of about two dioptries in the right eye. Atropine ($\frac{1}{12}$) was used in the right eye. Two days later, the crossing having changed meanwhile to the right eye, atropine ($\frac{1}{24}$) was given, to be used night and morning in both eyes. At the end of a fortnight convex spectacles (+2.5 D, changed three weeks later to +2.D, and after ten months to +1.75D) were given, to be worn constantly. At the end of two years fixation was alternate, the crossing noticeably less, and vision 15/xv with either eye. At the end of six years, wearing +1.25D right and left, fixation was with the right eye for distance, and with the left eye in reading; with somewhat greater range of adduction in the left eye. The parents now consenting to an operation, the tendon of the rectus internus was divided in the left eye, and, sixteen months later, in the right eye. Six months after the second operation the eyes looked perfectly straight, and there was no change in direction in alternate distant fixation; but a colored glass held before either eye evoked crossed doubling of a candle flame, estimated as of about three feet at a distance of fourteen feet. Haploscopic tests showed recognition of one or the other of the two test objects, but never of both objects at the same time. At the end of sixteen years—glasses having been discarded for distance about four years before—vision was 15/xii with either eye; the left eye was very slightly crossed, the crossing disappearing on looking through a pair of trial glasses (+0.75 D); crossed diplopia of about two feet at fourteen feet was evoked by the Maddox test; and tests with the stereoscope showed recognition of one of the two test-objects, or occasionally of both, but no indication of fusion of two images in a single visual impression. Reading spectacles (+3. D right and left), given after the operation on the second eye, were worn in all near work, but a change to +2.5 D was accepted as serving better in making and collating entries on large sheets of figures. The last examination—at the end of twenty-three years—showed no further change other than somewhat slower recognition of the persistent crossed doubling evoked by the Maddox test.

*Diplopia Monophthalmica*, or double vision with a single eye, is a result of the formation of two images of the same object on different parts of the same retina. If we look at a candle flame through two pinholes about three millimeters apart, pricked in a card, the flame will be seen single or double, according as the eye is accommodated for its distance or is not so accommodated. Similarly, in the somewhat rare case of a supernumerary pupil resulting perhaps from traumatism or from an imperfectly executed surgical operation involving the iris, the rays traversing the two pupils may fall together, when the eye is accurately adjusted for the distance of the object, or on different parts of the retina, when the eye is not so adjusted. The correction of the refraction by an appropriate spherical or cylindrical lens may suffice to fuse the two images.

"Seeing double" with one eye, or with both eyes, is a characteristic symptom in particular cases of regular astigmatism; as, for instance, in simple myopic astigmatism (see *Astigmatism*), in which the moon may look like two or more overlapping moons, and a cord or wire stretched in the direction of the ocular meridian at right angles to that of greatest refraction may be seen as two or more parallel cords.

Double vision in one eye, occurring sometimes as a premonitory symptom of cataract, may be a particular case of *polyopia monophthalmica* (see *Astigmatism*, under the sub-title, *Irregular Astigmatism* dependent on incongruous refraction through different sectors of the crystalline lens).

Diplopia in a child, when it is of a type and grade to be overcome by faulty carriage of the head, may be the predisposing cause of asymmetrical development of the bones of the face, of torticollis, or of scoliosis.

The study of diplopia, in so far as it connotes a central lesion implicating the nuclei of one or more of the cranial nerves, plays a principal part in the clinical localization of cerebral tumors. JOHN GREEN.

**Diplopoda.**—The class of arthropods which includes the centipedes. The bites of certain large species may cause inflammation accompanied by some pain; a few small species have been recorded as accidental parasites in the human intestine. See *Insects, poisonous.* A. S. P.

**Diploscope.**—An instrument devised by Dr. Remy of Dijon, France, in 1902; Remy is a military surgeon, and was led to inventing it, owing to the many subterfuges resorted to, by those seeking to avoid military duty, by alleging defective eyesight.

The diploscope is based on the principle of physiological diplopia.

If two lighted candles are placed on a table one in front of the other, "A," two feet distant from the observer, and the second one "B" four feet, the observer gazing intently at "B," the candle "A" will appear double, and the diplopia will be crossed. The reverse takes place when "A" is fixed upon, then the second candle "B" appears double and the images are homonymous.

The purpose of the instrument is to determine and measure the various deviations of binocular vision.

It consists of a tripod holding a cylinder having a long and a short tube. The long tube at first was

made 200 millimeters long, and 90 millimeters in diameter. The short tube is now only used as it is found to be satisfactory for moderate distance, as well as nearby. This tube has a diaphragm with openings in it, a chin rest, etc. The patient looks through the tube at various combinations of letters or words, the examiner watching the movements of the examined eyes, and the replies to the things seen showing him whether one or both eyes are being used.

It is useful in detecting any simulation of ocular disease.

The diploscope has been modified by Bourdeaux of France, Bjerke of Linpöping, Sweden, and Remy himself.

It is not in use in the United States, and the most recent text-book on ophthalmology does not mention it. For further details as to its many uses and the combinations of letters and their value in determining the muscular deviations we refer to Encyclopædie d'Ophthalmologie, vols. iv., viii., ix., Archiv für Ophth., vol. lxxvii, 1910.

WILLIAM OLIVER MOORE.

**Dippel's Animal Oil.**—(*Animal Oil; Ethereal Animal Oil.*) By the dry distillation of bone, horn, and animal substances generally, an oily liquid is produced, which was formerly used in medicine under the common name of Dippel's oil or Dippel's animal oil. The oil, when purified, is a thin, colorless, or yellowish fluid, of a pungent, ethereal, and smoky flavor. It is a very composite body, containing among other things quite a number of organic bases. Physiologically it is neurotic and irritant, and has proved fatally poisonous in doses of a tablespoonful. It was formerly prescribed internally in doses of a few drops, or used externally as an irritant embrocation, clear or as an ingredient of composite liniments. At the present time it is seldom, if ever, employed by the physician.

EDWARD CURTIS.
R. J. E. SCOTT.

**Diptera.**—The large order of insects which includes the flies, mosquitos, midges, etc. There are two well-developed transparent wings and two rudimentary wings, or halteres, behind them; the mouth parts are well developed and fitted for biting or sucking; the metamorphosis is complete. These insects come into relation with man as blood suckers, which may not only inflict poisonous bites but also carry diseases, as parasites during larval stages, and as spreaders of disease through contact with food.

There are three suborders, and the fleas, Siphonaptera, are sometimes included as a fourth.

Order 1.—Orthorrhapha—Mosquitos, midges, blackflies, horse-flies, etc.
Order 2.—Cyclorrhapha—House flies, etc.
Order 3.—Pupipara—Degenerate, often wingless flies, parasitic on vertebrates.

A. S. PEARSE.

**Dipteryx.**—TONKA, *Tonka Bean, Tonquin Bean.* The prepared ripe seed of various species of *Coumarouna* (Fam. *Papilionaceæ*). These seeds are produced by large and handsome forest trees of the Orinoco and Amazon River basins. The fruit considerably resembles a medium-sized peach in external appearance, but it is a thick-walled legume, with fibrous fleshy pericarp and is split open for the extraction of its solitary large seed. When first removed, this seed has no characteristic odor or taste. It contains a glucoside which, under suitable conditions, yields the aromatic substance cumarin in large amount. The ordinary method of developing this principle is to soak the seeds in weak alcohol, usually in the native rum, for some time. The cumarin then forms in crystals on the outer surface and in the cavity between the cotyledons. The tonka bean is black and of a leathery and wrinkled appearance externally. It is usually from three-fourths to one and one-half inches long and about a third as wide and is somewhat flattened. One edge and one end are thin and sharp. Its cotyledons are brown and fleshy and exhibit between their surfaces a pinnate plumule. It has a strong odor of cumarin, which is its only useful constituent. It is wholly employed for flavoring and perfuming, mostly as a substitute for vanilla.

H. H. RUSBY.

**Dipylidiinæ.**—The subfamily of tapeworms, family Tæniidæ, in which the scolex has an armed rostellum and unarmed suckers; the eggs have thin transparent shells. *Dipylidium, Hymenolepsis,* and *Drepanidotænia* are the genera. See *Cestoda.*

A. S. P.

**Dipylidium.**—A genus of tapeworms, *Tæniidæ,* in which the animals are of medium size, with a retractile rostellum armed with several rings of alternating hooks; genitalia duplicated, with pores on each side of the proglottid; eggs with a double shell. *D. canium* is found in the dog, cat, and man. Its larval development takes place in a louse or flea. See *Cestoda.*

A. S. P.

**Direction, Judgment of.**—It is proposed to consider here the judgment of direction of such objects only as are outside the body and not in contact with it.

HEAT AND COLD.—The direction of an object capable of producing either of these sensations can be roughly estimated by inference from the part of the skin affected, but the judgments thus made are of little importance in normal persons. In the blind, however, these sensations are much used, forming an important portion of those involved in "facial perception."

SOUND.—Sound waves also offer some data for judging direction. The following account of the phenomena is taken from Wundt. The concha acts as a condenser, specially collecting those waves which come from in front. The same sound is therefore heard more intensely when coming from that direction. This fact is brought out by an experiment where the conchas are bound down and some apparatus representing them is attached to the sides of the head, with the concavity directed backward. By this device the natural conditions are reversed, and sounds coming from behind are thus heard more distinctly and are then wrongly judged to come from in front. It has been suggested that the tactile sensibility of the concha, re-enforced by the hairs on it, may, in the case of loud sounds, be a means of indicating the direction. But this explanation is not sufficient, for in the case of faint sounds discriminations between "right" and "left" can be more easily made than between "in front" and "behind," while with sounds coming from in front it is possible, to a certain extent, to determine the angle formed by the line of the sound waves with the median vertical plane of the body. Since the closing of one ear destroys this localization of direction, the latter must be considered as a function of binaural audition. When certain partial tones are intensified by the resonance in the external meatus, then the relative intensity of the sensation in the two ears has an influence. It is probably due to the latter cause that noises in which, as a rule, high resonating overtones exist, are more exactly localized than simple notes. In the studies on the monaural localization of sound made by Angell and Fite, it was found that the judgment of direction was very accurate in persons depending on one ear only, and depended largely on

the quality of the sound coming from different directions. It is possible that certain muscular and tactile sensations should also be here included. Ed. Weber conjectured that the tympanum felt its own vibrations. It better accords with the results of other experiments, however, to consider that the action of the tensor tympani muscle, by its involuntary accommodation to sounds of different intensities, thus accompanies auditory impressions with muscle sensations of varying strengths. In cases of auditory hyperesthesia, affecting one ear alone, errors of judgment may arise, owing to the fact that a sound coming from the side *opposite* to the hyperesthesia may nevertheless cause a so much stronger sensation that the patient completely misjudges its direction.

Light.—Sight is the sense through which the chief judgments of direction are made. In all cases the direction of an object is represented by a line joining the body with the object, and objects on that line or its continuation are considered to have identical directions. The phenomena are first to be considered for one eye alone, the field of vision being stationary. When the image falls on a part of the retina other than the fovea, the eye must be turned in order to bring the image on that point, and for this purpose it must be moved by its muscles. In performing such a muscular movement there are at least two sensations which may be recognized: the innervation feeling and the tension of the muscles. When the eyeball is pulled to one side by the hand, objects in the field of vision appear to move, and the eye to remain quiet; at the same time, pulling the eye changes the tension of the muscles; nevertheless, neither the movement of the eye by a means other than the contraction of its own muscles, nor the tension of the muscles due to the same cause is recognized as a motion of the eye, and so objects appear to move in a direction opposite to that in which the eye is pulled.

In patients having the musculi recti paralyzed, an attempt to contract a rectus is followed by an apparent motion of objects in a direction opposite to that in which it is willed to move the eye. In this case there is present neither the contraction of the muscle nor any result of the exertion, but merely the innervation feeling; yet, from this arises a subjective sensation of motion. Since the innervation feeling can produce this result, it is argued that our judgment of the direction of an object seen is based on the remembrance of the innervation feeling necessary to bring the eye into such a position that the image shall fall on the fovea.

The only result of the innervation impulse which we plainly recognize in the eye is the altered position of objects in the field of vision. This alteration, bringing with it a variation in the position of the image, can be shown to act as a control on innervation efforts.

If a prism be put before the eye so as to cause the rays from a given object to fall on a new part of the retina—the object, for example, having thus been apparently moved to the left—and then, the eyes being closed, if the hand is stretched in the supposed direction, it will fail to touch the object, passing by it to the left. On touching the object, however, with the eyes open, and associating thus the new position of the image with fresh tactile sensations, a new combination is developed by which it can be inferred from the position of the retinal image where the hand must be placed to touch the object.

When two eyes are used the conditions are somewhat complicated, for one eye influences the judgments derived from the other. Helmholtz gives the following illustration: When one eye is closed, both axes being kept parallel, and first a distant then a very near object is fixated, both having identical directions, no change occurs in their apparent position in the field so long as the eye is simply focussed from one to the other. If, however, the near object be fixated and the closed eye be now converged so as to occupy the position necessary to fixate it if it were open, a marked apparent motion takes place in the distant object in such a way that, if we consider the left eye as the one open during the experiment, the distant object moves from right to left. On again making the axes parallel, it resumes its former position. The sense of direction, as derived from one eye, must accordingly be considered modifiable by the other eye, even though the latter remains closed. In an analogous way the judgment of horizontal and vertical lines is found to be influenced by the motions of the closed eye. For instance, with the axes parallel, one eye being closed, a thread forming the diameter of a short circular tube, when judged to be vertical or horizontal, is found to be really so, though by putting the head in different positions during the experiment the retinal horizon of the observing eye may, in certain of these positions, make an angle of even ten degrees with the true horizon. When, however, the previously parallel axes are converged, and the individual fixates a point on the thread, the line which was previously horizontal is now seen to undergo apparent rotation of such a nature that it corresponds with the rotation of the retinal horizon of the closed eye. Suppose in this case the right eye to be open, then on converging the left (closed) eye the right end of the thread apparently sinks while the left rises. The position of the eyeballs is found to be in part under the reflex control of impulses from the semicircular canals, and for this reason all judgments modified by the position of the eyeballs tend to be also modified by changes in the position of the head.

In the section on judgment of direction Helmholtz treats of a number of cases in which the objects viewed are in motion, for example, falling water. One who has watched a waterfall for a time notices, on looking at the bank, that objects there appear to move in a direction opposite to that of the water. The explanation offered by Helmholtz is that the eye, in order to view the falling water, continued to follow it downward for a time, then twitched up only again to follow it down, and so on. On now directing the gaze to the bank, the objects there apparently move in the opposite direction because the observer is unconsciously still continuing the same movements of the eyes as when gazing at the waterfall, and because this motion is unconscious the objects on the bank are consequently judged to move. The objection to this explanation of these illusions of motion is that they can be obtained in the after-image with the eyes closed, and, further, that two opposite motions can be simultaneously produced in the same retina. These facts, which with others were brought out by Bowditch and Hall, conclusively show that the explanation of Helmholtz will not apply in these cases. No other explanation of the phenomena is, however, at present formulated.

In considering the center to which these lines of direction are referred, E. Hering drew attention to the fact that we perceive the direction of objects seen as if both eyes were fused into one, and that one was located in the median plane of the head. This cyclopean eye is considered as so constructed that the retinal images are projected outward in the line of vision of that eye.

The habit of thus attending only to the mean direction of the lines of sight is considered by Helmholtz to depend on the fact that the median vertical plane of the body is the one to which all objects are referred, so that an object neither right nor left lies in that plane, which also passes midway between the two eyes. Further, an object may lie to the right or left of this plane and bear the reverse relation to the vertical plane (parallel to the median vertical plane) of the homonymous eye. In practice, we thus fuse the directions of both the optic axes and refer the lines of sight to a point in the head midway between the two

eyes. That this process results from habit is indicated by the fact that variations occur in the location of the cyclopean eye, and that fixation of the attention on the impressions from one eye alone serves to make that for the time being the reference point. Other observations indicate the same conclusion.

The above statements are mainly from Helmholtz's "Physiologische Optik," where they are elaborated. HENRY HERBERT DONALDSON.

**Disinfectants.**—Before it is possible intelligently to discuss the methods of action and the relative values of those agents which act detrimentally to the growth and multiplication of microorganisms, it will be necessary to consider, even though briefly, a few of the more important facts and theories of microbiology. Microorganisms are unicellular structures which possess a more or less well-differentiated cell membrane. Through this membrane diffuse in solution the substances which act as food to the cell and those which the cell is excreting. Under the most favorable circumstances the cell obtains the food best adapted to its needs, rids itself easily of its excretions, and multiplies rapidly. The optimum conditions involve certain more or less rigidly fixed quantities of light, heat, moisture, oxygen, food, absence of deleterious substances, and substrate. These conditions differ of course with the individual organism, but with the optimum conditions for any given bacterium growth, reproduction and the excretion of cellular products proceed rapidly, regularly, and indefinitely. If now one or more of these conditions be departed from in any considerable degree the cell reacts by developing less vigorously or not at all or even along entirely different lines than formerly. The greater the deviation from the optimum, the greater will be the difficulty experienced by the cell in its struggle for existence and at some point along the line when the effort becomes too great, death of the cell results. It is therefore easy to understand that in a gradual series of changes which might take place if the temperature surrounding a culture were raised, for instance, it would be extremely difficult to fix a definite point at which the cell would begin to suffer or even at which death would occur. As a matter of fact it has been observed that in any culture containing a large number of bacteria the cells show marked individual differences. Thus the older members of a colony may die from the effect of adverse conditions before the youngest and most vigorous ones begin to show serious ill effects. Moreover, it has been demonstrated that when a culture is acted upon by a disinfectant the action proceeds according to a definite known law, the rate of action at any given moment being proportional to the concentration of the surviving bacteria. It is obvious therefore that any consideration of questions concerning the effect of external agents upon bacteria must be conducted with the greatest caution and with due regard to all the biological conditions present at the time.

The semipermeable membrane, which constitutes the shell or covering of the majority if not all of the pathogenic microorganisms, occupies a position of the highest importance in all the life processes of the bacterial cell. It is through this membrane, by a process of more or less selective diffusion or osmosis, that the cell obtains its food from its surroundings and rids itself of excretory products, which are frequently toxins. Under unfavorable conditions, some bacteria are able to change the character of this membrane so that it becomes hard, dense, and impermeable. Such spores, as they are called, are extraordinarily resistant to the action of all deleterious agents and constitute an important method of defense on the part of these organisms. The phenomena of plasmolysis and plasmoptysis are believed to be due entirely to the "semipermeability" of this membrane. Water diffuses through it more rapidly than substances in solution and some substances will not diffuse through it at all. It is impossible to say whether the membrane itself exerts any selective action upon the materials in the fluid surrounding the cell. It seems more probable that the slight choosing power which resides in the bacteria and which is well demonstrated in the phenomenon of chemotaxis, resides in the cytoplasm. The power of the membrane to act as a barrier results in a number of very interesting occurrences which take place under certain conditions.

If bacteria are placed in a solution which is more concentrated than that to which they are normally accustomed, that is a hypertonic solution, they can be seen to present, after a time, certain changes. The cytoplasm, which normally fills the entire cell, shrinks so that it now occupies only a portion of it and there is a clear space between the cell body and the membrane surrounding it. This phenomenon is known as plasmolysis. The high osmotic pressure of the surrounding fluid causes water to diffuse out from the cell and in consequence the cytoplasm shrinks. As time goes on the substance in solution diffuses into the cell and the cytoplasm may tend to reassume its normal appearance. If the difference between the osmotic pressure within and without the cell is not very great the initial shrinkage may be too slight to be seen and the subsequent diffusion inward of the solute will soon restore normal relations between the bacterium and its environment. By slow and careful changes in the concentration of a culture fluid, an organism can in this way become "adapted" to life in the higher concentration though of course there is a limit to the extent to which this can be done. An organism which has been thus "adapted" to a changed concentration behaves henceforth as though this were its normal habitat and any subsequent sudden change will produce a definite reaction even though that change is one that restores the normal conditions for the organism. Urea, glycerin, antipyrin, chloral hydrate, and perhaps all substances which are soluble in lipoids, as a rule, do not cause forth plasmolysis. They probably diffuse readily through the cell membrane and therefore osmotic conditions inside the cell easily keep pace with those in the surrounding medium. Plasmolysis is a reaction of living protoplasm and a cell once dead is no longer plasmolysable. What is more, plasmolysis evidently does not result in the immediate death of the cell, for if the organism, after being subjected to immersion in a fluid of high concentration, is returned to its normal surroundings, the water gradually diffuses back into the cell which thereupon resumes its normal appearance and ability to functionate. As a matter of fact plasmolysis not infrequently occurs spontaneously in cultures in consequence of an evaporation of the medium and it is claimed that the irregularity in staining which is characteristic of the diphtheria bacillus under certain conditions, is due to the occurrence of plasmolysis. While it is true that plasmolysis does not involve the immediate death of the microorganism, nevertheless bacteria may be killed by prolonged immersion in very concentrated solutions. It is certain that the cell suffers an inhibition of its functions at an early stage in the development of such a concentration and this fact has been utilized in the preservation of food stuffs. Brine for the preservation of meat and fish and syrup for fruits will serve as two familiar examples of the way in which concentrated solutions will prevent the growth of the putrefactive bacteria. The prime advantage of such methods is that they are cheap and harmless. There are a few organisms which do not undergo plasmolysis. They are supposed not to have any cell membrane.

If bacteria are placed in a hypotonic solution, one with a diminished salt content and therefore with a diminished osmotic pressure, the result may be a change which is the opposite of that taking place in

plasmolysis. Water diffuses rapidly into the cell which becomes more and more swollen until finally the membrane ruptures and the cytoplasm escapes. This is known as plasmoptysis. It has been quite extensively described by Fischer but its existence is denied by many other investigators who claim that at least a portion of his results were due to contamination of his cover-glasses. It is obviously a much more serious happening for the organism, but even here some bacteria apparently have the ability to develop a new membrane around the naked globule of cytoplasm. Plasmoptysis, if it occurs, is closely allied to the so-called lysis which takes place when bacteria are subjected to the action of bacteriolytic sera, although in the latter case it is hardly probable that the lysis is due merely to a change in osmotic pressures. Whether or not there is satisfactory proof of the existence of plasmoptysis it is indisputable that hypotonic solutions are bactericidal to a greater or less degree. All vegetative forms of bacteria will eventually die if they are kept in distilled water which of course is the greatest of hypotonic solutions. Ten million cholera vibrios added to 1 c.c. of distilled water died within one week. It has been claimed that this action is one simply of starvation and in support of this claim has been presented the fact that when a very large number of bacteria are added to distilled water the curve representing the number of live cells is not a steadily declining one but zigzags downward presenting temporary rises. It is said that the death of some of the cells sets free a certain amount of nutriment so that the remaining cells are enabled for a short time to multiply again. This food is soon used up and another decline takes place. This is followed by another slight rise and so on. It is objected, however, that the bactericidal power of distilled water is impaired by the presence in it of minute quantities of substances dissolved from the containers. Water which has been boiled for a long time in vessels of little resistance will have much less bactericidal power than that which is kept in Jena glass vessels of high resistance and at low temperatures. This latter fact would seem to negative the claim that the bactericidal action of distilled water is wholly one of starvation. On the other hand, extraordinarily minute quantities of metals in solution may increase the bactericidal powers of distilled water to an amazing extent. Water that had stood in the ordinary lead water pipe for ten hours killed all of twenty million cholera bacilli in four hours. A vessel which had contained a one in fifty million solution of copper sulphate was rinsed several times with distilled water and then filled with pure distilled water. This water was much more energetically bactericidal than another portion of the same water which had been kept in a clean vessel. This is known as the "oligodynamic influence" of metals in solution and is an action that is but little understood though well established.

Bacteriolysis may also result from the action of a number of chemical agents. When the cell body goes into solution, leaving the empty cell membrane, the process is called chromatolysis while if only the membrane is attacked it is called stromatolysis. Autolysis takes place when the lytic action is brought about by the products of the bacteria themselves. Lysis may occur also from the action of blood serum or in some cases may be a true digestion by some of the well-known digestive ferments. Distilled water is chromatolytic in its action, as are such substances as ethylamin, ammonium nucleate, glutaminic acid, and caffeine. Stromatolysis is caused by alkalies and strong salt solutions. There is a very great difference among the bacteria in the way they react to these lytic substances. Bile salts, for instance, have a powerful lytic effect upon the pneumococcus. The true meningococcus is dissolved while the Jäger meningococcus and the pus cocci are not affected. Bile salts, cobra venom, and oleic acid dissolve protozoa. On the other hand, glycerin acts upon many bacteria but not upon the protozoa or some of the so-called "filterable viruses." The last fact is used practically in the preservation of smallpox vaccine which is mixed with glycerin to prevent the development of the ordinary pathogenic bacteria.

Autolysis is thought by some to result from the action of a ferment, endotryptase, contained within the cell and therefore to be a self-digestion. The action takes place only when conditions are not favorable for growth and multiplication, as when the temperature is a little too high or too low, or in the presence of substances which injure or kill the organism. Examples of such substances are chloroform, toluol, thymol, and salicylic acid. If the disinfectant action is too strong, however, the ferment also is killed and the autolysis does not take place. Autolysis also takes place in old cultures. Pneumococci, gonococci, and meningococci will grow vigorously for a short time in a suitable medium and then gradually disappear. The disappearance is due to autolysis. The readiness with which autolysis occurs is governed to a certain extent by the fluid in which the bacteria are contained. It is said to occur most readily in serum and least so in distilled water. In physiological salt solution there is always a certain amount of autolysis which is induced partly because of the insufficiency of food material and partly through the influence of the ionic action of the solution.

Most fresh normal sera exhibit bacteriolytic properties and this power is tremendously increased in those sera which contain in addition specific bacteriolysins. The nature of this action is but little understood and need not concern us here. The organisms usually first show granular degeneration and the process is apparently the same as that which occurs when the bacterium is ingested by a phagocyte. The resistance to lysis is varied as we have seen. For any given organism, however, the younger it is the more resistant it will be. Spores are exceedingly resistant and rarely undergo lysis. The acid-fast bacteria are almost as resistant as the spores while the Gram-positive organisms are much more resistant than the Gram-negative ones. The one striking exception to this rule is the pneumococcus which, although Gram-positive, is very susceptible to most of the lytic agents.

Living bacteria are attacked by the ordinary digestive ferments to a very slight degree if at all. The Gram-negative bacteria when killed by a temperature of from 75° to 80° C. are readily attacked by pepsin and trypsin. The Gram-positive organisms on the contrary are not attacked by trypsin even after death. Bacterial extracts are found as a rule to contain "trypsin-binding" substances. One substance which is frequently included among the ferments must be considered here. The *B. pyocyaneus* produces a substance which has been called pyocyanase and which has definite bactericidal powers. It is able to kill the diphtheria bacillus in ten minutes and the pus cocci after two days. The nature of the action is not known but its apparently selective action upon the diphtheria bacillus has induced many to advise its use in the treatment of that disease. No statistics are available on that subject at the present time.

The bacterial cytoplasm is made up in part of protein which under certain conditions coagulates, becomes "denatured" as it is sometimes called. When so denatured the protein is permanently altered and an organism whose cytoplasm has coagulated is dead. Many of the disinfecting agencies act by coagulating the bacterial cytoplasm and it is interesting to note that in the case of heat, surely, and probably in the case of the chemical disinfectants, the ease with which the protein becomes denatured depends to a large extent upon its water content. Thus an albumin in solution in an excess of water may coagulate at 58° while if it contains but six per cent. of water, coagulation takes place only when the temperature

reaches 145°, and when absolutely water-free demands a temperature of 170° before it becomes denatured. The importance of the presence of sufficient water will be pointed out again in the consideration of the individual disinfectants. It is due partly to their low water content and partly to their resistant membrane that spores are able to remain unchanged in such adverse surroundings.

From a consideration of the above phenomena of microbiology it will be understood that it is exceedingly difficult sharply to classify physical and chemical agents as antiseptic, disinfectant, or germicide. For instance, a given organism for its optimum conditions demands, among other things, a certain percentage of salts in the medium in which it grows. Increase that percentage by even a very minute amount and the growth will be perceptibly though not seriously affected. Increase it to a greater degree and the growth becomes markedly inhibited. If the medium becomes a highly concentrated solution of these necessary salts inhibition will be complete and if the bacteria are permitted to remain in this solution for a sufficient length of time death of the cell occurs. Spores will not, however, be affected by such a solution. It is impossible to say at what point in this gradual concentration, the fluid ceases to exercise merely a plasmolytic action and becomes actively antiseptic or where it may develop bactericidal qualities. To take another instance: Many organisms when acted upon by chloroform readily undergo autolysis. Some investigators have gone so far as to say that chloroform in itself has no bactericidal action but merely forces the cell to commit suicide, as it were. Pasteur found that the anthrax bacillus grows best at 37° C. When he grew it at 42° its virulence was lessened to such an extent that cultures grown at this temperature could be used for the prophylactic inoculation of sheep. What is the relation of the attenuating and the antiseptic action of heat in this instance? Any answer to these questions must necessarily be more or less a matter of opinion. The words preservative, antiseptic, disinfectant, germicide, and bactericide have been used very loosely in the past and only recently a new one, kolyseptic, has been introduced to join them. The prevention of bacterial activity, especially that of a putrefactive nature, by the use of such agents as brine, syrup, and cold cannot rightly be classed as antisepsis. They have long been classed as preservatives and usage often has a right that is denied to derivation. We should therefore limit our definitions as follows:

Those *chemical* substances which suppress certain functions of microorganisms, inhibiting their development but not killing them, are known as *antiseptics*. If the bacteria are removed from the influence of an antiseptic they will be able to resume the function of multiplication. In many instances, substances in a certain dilution act as antiseptics but when employed in stronger concentrations have the power of killing bacteria, that is, become germicides or disinfectants. Kolyseptic is synonymous with antiseptic.

Those agents, whether physical, chemical, or mechanical, which bring about the death of microorganisms are known as *germicides* or *disinfectants*. The two terms are synonymous. Disinfection has further been divided for practical purposes into two groups. Agents which kill only the vegetative forms leaving the spores intact are called *incomplete disinfectants*. Those which kill both vegetative and spore forms, completely sterilizing the material, are called *complete disinfectants*.

Estimation of Disinfectant Power.—The estimation of the absolute antiseptic or disinfectant power of any agent is a matter attended by enormous difficulties. The medium, temperature, light, duration of the action, the age of the culture tested, the presence or absence of spores, the relative quantities of bacteria and disinfectant, the presence of gases and moisture, these are all important factors which must be controlled in order that any estimation be of value. Not less important is the nature of the disinfecting agent, its ionic dissociation, concentration, and stability, and the nature of the solvent. The disinfecting agent must further be removable or neutralizable without injury to the organisms. Further difficulties arise in the determination whether death of the bacteria has really occurred. This has been done in two ways. After removal of the disinfectant the emulsion may be injected into some susceptible animal. This method is reliable when the animal dies or becomes sick. Negative results, however, do not mean very much. Attempts to cultivate the organism are usually more fruitful. Here care must be taken completely to remove or neutralize the disinfectant and also to choose a suitable medium. It has only recently been shown that many of the results of disinfection experiments in which the anthrax bacillus has been used are open to question since when this organism is nearly killed it may not grow out in broth but readily does so on agar media. Still a great amount of good work has been done and its results are very helpful in the consideration of the value of disinfectants. The estimation of the relative disinfectant or antiseptic power, while requiring a vast amount of patience and care, is still comparatively easy. Such relative values are of service in that they furnish comparative figures which enable the laboratory worker or sanitarian to choose intelligently from among the large number of agents offered. There have been proposed several methods for the estimation of this relative disinfectant power. The best known probably is that of Rideal and Walker. These authors worked with standard conditions using pure phenol as the standard substance. They arrived at their "phenol coefficient" by dividing the figure indicating the degree of dilution of the disinfectant that kills an organism in a given time, by that expressing the degree of dilution of phenol which kills the organism in the same time under exactly similar conditions. This method was not without faults in that the dilutions were not fixed and in this manner the coefficients obtained might differ widely. The process was carried out at variable temperatures and the tubes were inoculated with "one drop" of the culture, the objection being that a drop is a variable quantity.

An improvement was offered in the method devised by the commission authorized by the *Lancet*. The "*Lancet* coefficient" is obtained as follows: The figure representing the percentage strength of the weakest killing dilution of phenol is divided by the figure representing the percentage strength of the weakest killing dilution of the disinfectant, both at two and a half and at thirty minutes. The mean resulting figure is taken as the true coefficient. The commission used the *B. coli* instead of the *B. typhosus*, MacConkey's bile salt medium instead of broth, and spoons for transferring instead of standard loops. The chief objections to this method are that the *B. coli* is a very variable organism, that the dilutions are fixed by the worker, and that the medium may have a restraining influence upon the attenuated organisms.

Rather recently Anderson and McClintic of the Hygienic Laboratory of the United States Public Health Service have devised a method for obtaining what they style the "Hygienic Laboratory coefficient." This method is probably the best which has been proposed and as it will undoubtedly be used largely in this country, especially by manufacturers for estimating the value of their products, it can be considered rather fully. The organism used is the *B. typhosus* and in similar tests the same strain should be used if possible. Before using it should be carried over daily on broth for a period of one week. The twenty-four hour culture in broth is shaken and fil-

tered through sterile filter paper into sterile tubes and warmed to the standard temperature. The medium used is an extract broth which is always made in exactly the same way and should have a reaction of +1.5. A standard platinum loop of four millimeters diameter made of 23 U. S. standard gauge wire is used and all action is carried on at a temperature of 20°. The tubes are one by three inches in size. The standard solution contains exactly five per cent. by weight of pure phenol (Merck) and the higher dilutions are made fresh daily. Standard pipettes and cylinders are used for making up the dilutions which are carried out with the greatest care according to the following scheme:

From $\frac{1}{10}$ to $\frac{1}{70}$ by 5's.
From $\frac{1}{70}$ to $\frac{1}{180}$ by 10's.
From $\frac{1}{180}$ to $\frac{1}{280}$ by 20's.
From $\frac{1}{280}$ to $\frac{1}{480}$ by 25's.
From $\frac{1}{480}$ to $\frac{1}{980}$ by 50's.
From $\frac{1}{980}$ to $\frac{1}{1800}$ by 100's.
From $\frac{1}{1800}$ to $\frac{1}{3200}$ by 200's.

The technique is as follows: 10 c.c. of the diluted disinfectant and of the phenol dilutions are placed in test-tubes which are kept at 20° by means of a water bath. 0.1 c.c. of the typhoid culture, prepared as directed above, is added to each tube. Every two and a half minutes up to and including fifteen minutes, a loopful is transferred from each tube to a culture tube containing extract broth and these tubes are then incubated at thirty-seven degrees for forty-eight hours. The figure representing the degree of dilution of the weakest killing strength of the disinfectant is divided by the figure representing the degree of dilution of the weakest killing strength of phenol both for two and a half and for fifteen minutes. The sum of these two figures when divided by two gives the coefficient of the disinfectant used when referred to pure phenol. It will be noted that in this method as described the action of the disinfectant takes place in the absence of organic material and it will be seen later that disinfectants differ greatly in the way they act in the presence of organic matter. In order to obtain a coefficient of their value under such conditions the method may be varied by adding to 4 c.c. of the diluted disinfectant, 1 c.c. of a solution of ten per cent. peptone and five per cent. gelatine, thus giving three per cent. organic matter in the resultant mixture. Another important consideration is the cost per unit of efficiency. This is obtained by dividing the price per gallon of the disinfectant by the price per gallon of pure phenol and dividing the price ratio so obtained by the phenol coefficient which gives the cost per unit of efficiency as compared with phenol as one. At the end of this article can be found a list of a few of the popular disinfectants whose phenol coefficient has been estimated according to this method.

We can now proceed to a discussion of the individual disinfecting agents and since many of these are either antiseptic or disinfectant depending upon whether they are concentrated or dilute, we shall make no attempt to divide them according to any such classification. It should be noted that no attempt will be made to include the so-called biological agents. All fresh normal blood serum has a certain amount of disinfecting power and following inoculation this power may be raised to an extraordinary degree. The discussion of this action belongs, however, to the domain of immunity and may be found in the article under that title.

Mechanical Agents.—*Filtration.*—The sterilization of fluids by passing them through filters of porcelain or infusorial earth is very complete. Since, however, this process does not involve the death of the bacteria it cannot properly be included. It should be remembered that only those organisms are removed whose large size prevents their passage through the pores of the filter and that there are a number of so-called "filterable viruses" which can easily pass the finest filter known. The partial disinfection of drinking water by passage through a filter-bed is only in part a filtration. A large part of this disinfection is accomplished by the antagonistic action of certain saprophytic bacteria which develop in the bed and which are able to kill pathogenic forms.

*Centrifugation.*—Bacteria may be removed from fluid by the use of high power centrifuges but here again the process does not cause death of the bacteria and is therefore sterilization rather than disinfection.

*Trituration.*—Bacteria, preferably in a partially dried condition, may be ground in a mortar with sand and if care and patience is used this process can be carried to a complete destruction of all organisms. The method is, however, hardly adapted for practical purposes.

*Shaking.*—Prolonged and vigorous shaking may result in the death of all the bacteria in the fluid. This also is not a practical method of disinfection but has a certain amount of importance in the consideration of bacteriological technique.

Physical Agents.—*Pressure.*—Increase of pressure has an exceedingly slight influence upon microorganisms. It has been demonstrated that a pressure of from two to three thousand atmospheres has only a slight inhibitory influence upon streptococci.

*Light.*—The direct rays of the sun have long been known to have a very definite bactericidal power. In culture media all bacteria, even spores, have been killed after exposure to sunlight for five hours. The intensity of the action depends upon the intensity of the light and therefore direct sunlight is more powerful than diffused daylight and the light of the electric arc is weaker than that of the sun. Light has only moderate power of penetration and is therefore essentially a surface disinfectant. Still it has been observed to retain some of its bactericidal activity at a depth of three meters in clear river water and must therefore play an important part in the "self-purification of running streams." It has practically no power to penetrate turbid fluids and bacteria when protected by particles of mucus are very resistant to its effect. The most powerful bactericidal rays are those at the ultraviolet end of the spectrum. On this fact has been based a method for the sterilization of drinking water. The water is made to flow slowly around and past a vacuum tube in which the ultraviolet rays are generated electrically. It is absolutely essential that the water be perfectly clear and that it flow in a layer that is not too thick. The process has been found to be quite efficacious but is rather expensive. No heating takes place during the process. The explanation of the bactericidal action of light is unsatisfactory. It has been described as a photochemical action on the substrate or upon the cytoplasm of the cell. This action resulting in the formation of peroxides and the setting free of nascent oxygen is able to cause the death of the bacteria. This is probably only partly true. What bactericidal power resides in the rays at the red end of the spectrum owes its origin probably to the setting free of oxygen, but the ultraviolet rays are said to be able to act independently of the presence of free oxygen and certainly are able to kill dried bacteria. Whatever the nature of the process its practical application is clear. Pathogenic bacteria breed with facility in dark moist places and the application of large quantities of sunlight is very helpful in cleaning up an epidemic of infectious disease.

*Röntgen Rays, Becquerel Rays, and Radium Emanations.*—These agents have practically no bactericidal power though they may be able to exert a certain amount of antiseptic action. The statement has been made that the non-penetrating rays from radium will kill anthrax spores at a distance of not more than a few centimeters in the course of several days

*The Electric "Stream."*—This probably has no direct action though its power to cause decomposition in the substrate by means of electrolysis may result in the formation of substances which will injure the bacteria.

*Cold.*—In the majority of instances cold has little bactericidal effect unless continued over long periods of time and even then pathogenic organisms have been known to retain their vitality for as long as a year. Its antiseptic power, on the contrary, is very marked. Any lowering of the temperature has an adverse effect upon the growth of microorganisms and at the easily maintained temperature of 0° C. no growth occurs. For this reason cold storage is the most important single measure for the preservation of materials which are likely to undergo bacterial decomposition. A few of the less resistant bacteria such as the gonococcus and the pneumococcus are rather easily killed by low temperatures but infected water is practically unaltered by freezing for several months and such organisms as the staphylococcus and the typhoid bacillus are not killed even at the temperature of liquid air (−190° C.).

*Drying.*—All bacteria demand a high degree of moisture for their active growth and drying has always a certain amount of injurious influence. Complete drying has distinct antiseptic value since under these conditions no bacteria will grow. On this principle is based the drying of meats for their preservation, a practice which has been followed in certain parts of the country for a great many years. Whether desiccation has any value as a germicide is debatable. Some of the experiments which have been carried out to determine this point are open to objection for the concentration of the medium which takes place during its evaporation almost surely has an injurious influence. Recently it has been shown that if bacteria are rapidly frozen and then dried in a vacuum at a low temperature they not only are not injured but on the contrary preserve their activity and virulence for at least several months. On the other hand, as it occurs naturally, drying probably exerts a disinfectant action and the dust particles of the air only rarely carry living organisms.

*Heat.*—Heat is the most important of the physical agents of disinfection. It is cheap, can be accurately measured and easily controlled, and after its action is complete it is easily removed. For many purposes it is unexcelled, the chief objection to its general use being its destructive action upon many materials. In any discussion of the bactericidal action of high temperatures the remarks already made upon the coagulation of protein should be borne in mind. The presence of a certain amount of water is essential for effective action at reasonable low temperatures. Where the material to be disinfected is not affected by very high temperatures it can of course be sterilized easily regardless of the amount of water present. With this point in mind it will be advantageous to consider heat as being either dry or moist.

Dry Heat.—Apparatus that bears heating to a red heat, such as a platinum loop, is easily sterilized in the flame while infectious material is destroyed and rendered innocuous by burning. The application of these methods is of course limited. Under most conditions the application of a temperature of 165° for one hour will result in the complete destruction of all forms of bacteria. Dry heat, however, has but little power of penetration. A ball made of nineteen thicknesses of cotton wool was surrounded by a temperature of 140° for three hours and at the end of that time a thermometer in its interior showed that the temperature there had not risen above 35°. It has come therefore to be regarded chiefly as a surface disinfectant and is used for the sterilization of laboratory apparatus and glassware.

Moist Heat.—The application of heat in the presence of moisture is much more efficacious as a disinfectant measure. The slightest advance over the optimum temperature is injurious to bacteria and has therefore a certain amount of antiseptic action. This injury increases as the temperature rises until it is found that in the presence of sufficient moisture, vegetative forms die after exposure to 60° C. for fifteen minutes and after five minutes at 70° C. This temperature of course has no effect upon spores but the fact is applied in the method of discontinuous sterilization in which the material is heated to 60° for thirty minutes on each of three successive days. The intervals at normal temperature permit the development of the spores into vegetative forms which latter are killed during the heating on the following day. This method is especially adapted for use in the case of those materials which suffer decomposition at 100° or over. Exposure to boiling water will kill anthrax spores in less than five minutes and is a very active disinfecting agent. There are some spores which are able to resist this treatment for several hours but they are rare. Exposure to streaming steam at 100° is a good method and approximates boiling in its disinfectant power. The heat applied in this way is not very penetrating and organisms situated in the interior of packages may survive the process. Probably the most active form in which heat may be applied and at the same time one which is only slightly destructive, is that of saturated steam under increased pressure. In the use of this method it is essential that the apparatus be a good one and in good working order. Penetration is furthered by the exhaustion of air from the apparatus before the admission of the steam. With a good sterilizer all bacteria, whether as spores or as vegetative forms, are killed within fifteen minutes with only moderate increase in the pressure. It is quick and sure. Care must be taken that the steam be saturated, for here again moisture is essential. Superheated (dry) steam at 150°–200° has a disinfectant power which does not exceed that of saturated steam at 100°. In the last analysis, the efficacy of heat as a disinfectant depends upon three factors: The amount of water which is present in the protoplasm of the organism at the time, the penetration of the heat to every organism present, and the degree of effective heat attained. If these factors are kept in mind the application of heat for disinfectant purposes will always be successful.

Chemical Agents.—The ideal chemical disinfectant will possess certain characteristics. These have been formulated as follows: a high value in dilute solutions, easy solubility in water, unlimited action, low toxicity, no injurious action, no bad or lasting smell, and cheapness. It will be seen that none of those known at present can be considered to be truly ideal. They should be easily soluble in water since they, without exception, act best in watery solution. The reason is probably because only in water are they able to come intimately into contact with the bacterial cell and exert upon it their disinfectant action. Solutions in absolute alcohol or in oils usually have only slight if any bactericidal power. Where possible they should be permitted to exert their action in the absence of organic matter and most of them act best in pure water. Disinfectant action as a whole has been divided into two orders, the first in which the action is one of ions and the second in which it is one of molecules. In the case of salts the action may at times be considered as a threefold one since theoretically the dissociation is never absolute, that of the metallic ion, that of the acid ion, and that of the molecule. In the case of those salts which are dissociated, however, it has been found that the action of the molecule is a negligible one since their disinfectant power depends almost wholly upon the extent of their dissociation. In this connection it may be well to devote a few lines to the influence which is exerted by the addition of neutral salts to a solution of a disinfec-

tant. The presence of sodium chloride is said to lessen the disinfectant power of the bichloride of mercury. This action is due to the fact that it interferes with the dissociation of the latter substance. Practically, however, this does not constitute an objection to its use and many of the tablets of corrosive sublimate are made to contain a certain percentage of sodium chloride. The explanation for this apparent paradox is that the bichloride of mercury is used in such high dilutions that its dissociation is practically complete in spite of the presence of the salt. On the other hand the solution of the bichloride is hastened by the presence of the salt and the latter tends also to prevent the formation of insoluble compounds of mercury and albumin which will limit the action of the sublimate. The presence of neutral salts favors the action of many of the chemical disinfectants. This action is explained on various grounds. Some undoubtedly act by increasing the permeability of the bacterial membrane and thus render the entrance of the disinfectant more easy. Others of the neutral salts are soluble in lipoids and may act as a vehicle by the aid of which the chemical is able to penetrate into the organism. In the case of phenol it is said that neutral salts render it less soluble in the medium and more so in the protoplasm. It must be admitted that all these explanations are very similar and are equally unsatisfactory. In addition to any of these actions which a salt may have there are many which are in themselves quite strongly disinfectant and this influence cannot be ignored. It has been observed that those salts which are most strongly hemolytic have the greatest disinfectant power. Any disinfectant may be taken up into the body of the bacteria by means of a process of absorption or of adsorption. The latter process is important since by it a chemical in high dilution may be concentrated in the bacterial cell to a sufficient extent so that it acquires killing properties. It is possible that it is in this way that very weak solutions become germicidal after long action upon bacteria. Some chemicals seem to have a certain amount of elective affinity for particular cell receptors and as a result a combination of two disinfectants is often much more powerful than could be expected from the action of either one of them. This special affinity is also illustrated by the marked action which some chemicals have upon certain organisms. The influence of quinine upon the protozoon of malaria is a good instance of such affinity. Bactericidal action may be limited by the action of the germicide. If this substance renders the cell membrane less permeable or precipitates the proteins so that they form a protective wall about the bacteria its action is checked at least for the time and its usefulness restricted. The action of all of the chemical disinfectants is increased in the presence of heat, sometimes amazingly so. This fact is also important in its practical application. The coefficient of distribution of the disinfectant will of course determine its action, for example, phenol in solution in oil has little or no bactericidal action because its solubility in the oil is so great that there is no attraction for it to enter the body of the microorganism.

We shall now proceed to a discussion of the individual disinfectants. No pretence has been made to include a mention of all of the disinfecting substances which have appeared on the market, their number is far too great for an article of this scope. A few of them will be named and at the end of the article will be found a table in which the value of some of them is stated.

The Heavy Metals.—Bacteria may live and possibly multiply on the surface of pieces of metal; yet a piece of silver or gold or copper which has been placed in an infected agar plate will be surrounded by a sterile zone. This is an example of the oligodynamic action of the metal. In the form of colloids they may be quite energetically disinfectant, and colloidal silver especially has found a certain amount of favor.

Salts of the Heavy Metals.—*Mercury.*—Mercury bichloride is the most important of the chemical disinfectants. Its usefulness is limited by the fact of its extreme poisonous qualities and its corrosive action upon metals. Its strength depends upon the degree of its ionic dissociation but its power is so great that it is generally used in a dilution such that the ionization is practically complete. Its action is not limited by the presence of neutral salts when used in a dilution of 1–1,000 or more. On the other hand the addition of sodium chloride tends to prevent the formation of the insoluble albuminate of mercury, substituting therefor a soluble double salt. Corrosive sublimate will kill the most resistant spores in a few seconds when in a 1–500 solution and a solution of 1–1,000,000 in water has definite antiseptic action. The mercury salts rank in the order named in their disinfectant power: chloride, bromide, sulphocyanide, iodide, cyanide, nitrate, sulphate, and acetate. The character of the action is the same in each case. Mercury oxycyanide is a stronger antiseptic than the bichloride but is a weaker disinfectant. Its action is favored by the addition of sodium chloride. Mercury ethylendiamine sulphate, sublamine, is much less toxic than corrosive sublimate but is also a less powerful disinfectant. Asterol is paraphenylsulphonic acid mercuric ammonium acetate and is about one-half the strength of the bichloride.

*Silver.*—The action of the silver salts is unlimited in one direction since the compounds with albumin are in themselves bactericidal, but rather distinctly limited in another for the silver is precipitated by sodium chloride in the form of the very insoluble silver chloride. The nitrate is the most important salt. When used in serum it is five times as strong as corrosive sublimate. A 1–12,000 solution in serum will kill anthrax spores in seventy hours. Its action is greatly weakened in the presence of ammonia since in this form the silver is not present as a free ion. Of recent years a large number of silver compounds have appeared which are claimed to be less irritating to mucous membranes and which are not precipitated with sodium chloride. Argonin, protargol, largin, novargan, albargin, and argyrol are compounds of silver with casein, albumin, etc., whose value closely approximates that of the nitrate and which are adaptable for use in irrigation. Argentamine, ethylendiamine silver phosphate, is strongly bactericidal for vegetative forms but has little effect upon spores. Ichthargan is a compound of silver and ichthyol containing thirty-three per cent. silver and has a good bactericidal action. The lactate, actol, the citrate, itrol, and sophol which is a compound with methylene nucleinic acid have been recommended as disinfectants for internal use but are regarded as inferior to the colloidal silver for this purpose. Silver fluoride, tachiol, is about equal to the nitrate. Shortly after silver was first obtained in colloidal form it was noticed that if egg albumin was rubbed up with the new product it would keep indefinitely. Investigation revealed that colloidal silver, collargol, electrargol, was quite strongly disinfectant and could be used extensively in the treatment of disease. In this form it can be injected intravenously without ill effects and its use was advocated in all varieties of sepsis. It must be admitted that the results which have been obtained hitherto have been far from encouraging. The pyogenic cocci are killed in from thirty to forty-five minutes in a 1–200 solution of colloidal silver.

*Gold.*—Gold hydrochloride is the most efficient of the salts of gold. The cyanide compounds are almost without value.

*Copper.*—The bromide is the most powerful of the copper salts but is very susceptible of decomposition and therefore not reliable. Cupric chloride is considered the best for use in albuminous fluids. All copper solutions, however, have practically no sporicidal value and show their most marked effect

upon the algæ. For instance the presence of copper sulphate in the water of a pond in the proportion of one part in one million will kill off these plants and keep the water clean. In this dilution it is harmless to man and could therefore be used in drinking water.

*Iron.*—Among the salts of iron only those in which the metal exists as a free ion have any germicidal power. Thus the ferro- and ferricyanides are wholly worthless. The other salts are effective only in strong solutions. Ferric sulphate does not kill anthrax spores or tubercle bacilli even in thirty per cent. solution. A one per cent. solution is a fairly efficient antiseptic. The use of iron chloride has been recommended for the local treatment of diphtheria but its effect is due as much to its astringent action as to its bactericidal powers.

*Other metals* have as a rule but little action. The bichloride of platinum is said to be antiseptic in a dilution of 1–3,000 but it is a feeble germicide. Zinc chloride and cadmium chloride are antiseptic in 1–500 solutions and thallium carbonate in a proportion of 1–7,500 is said to prevent the development of anthrax bacilli in the blood serum. A four per cent. solution of aluminum acetate kills typhoid bacilli in twenty minutes and alsol, aluminum acetotartrate, is a sporicide in a five per cent. solution. Lead chloride, cobalt nitrate, nickel sulphate, and uranium nitrate are antiseptic in dilutions ranging from 1–500 to 1–350. None of these salts shows any definite disinfectant ability.

Alkalis.—The disinfectant power of the alkalis depends directly upon the degree of their ionic dissociation. Normal solutions of the hydroxides of sodium, potassium, and lithium are sporicidal in from eight to eighteen hours. One-fourth normal solutions kill staphylococci in ten minutes. Ammonium hydrate is of low value corresponding to its weakly alkaline properties. The action of all of the substances in this group is very greatly increased by heat. The alkaline carbonates are not sporicidal at ordinary temperatures in any dilution but at 85° a 1.4 per cent. solution of sodium carbonate will kill anthrax spores in ten minutes. The alkaline bicarbonates have no value. Hydroxylamine and hydrazine hydrate have considerable value as antiseptics but none as disinfectants.

The *alkaline soaps* have some disinfectant power even at room temperature, a six per cent. solution killing the typhoid bacillus in thirty minutes. They are used in the disinfection of hands and of clothing and very extensively so as a vehicle for a large class of chemicals, the cresols, which will be mentioned later.

One of the cheapest disinfectants and a very satisfactory one is *calcium hydrate*. As whitewash it has killed anthrax spores on walls, and the addition of unslaked lime is one of the best methods for the disinfection of stools. The action in this instance is favored by the heat that is developed. It is interesting to note that the action of the alkalis may be almost entirely a lytic one and it will be well to recall what has been said in the paragraph on the subject of lysis. A good example of the difference among organisms in their reaction to alkalis is seen in the use of antiformin for the demonstration of tubercle bacilli. Antiformin is a compound of chlorinated lime, sodium carbonate, and sodium hydrate and should contain about 5.6 per cent. of available chlorine. When sputum is mixed with antiformin the mucus and all the organisms except those which are acid-fast are dissolved while the tubercle bacilli are unaffected. Indeed if the process has been carried out at room temperature it is possible to culture out the tubercle bacillus from such a preparation. A five per cent. solution of antiformin will dissolve all the vegetative forms except the acid-fast ones in forty-five minutes. Spores are not completely dissolved in twenty-four hours. The bactericidal and lytic powers of the alkalis, however, do not always parallel each other.

Neutral Salts.—The action of the neutral salts depends upon that of the ions into which they are dissociated. Their germicidal action seems to parallel to a certain degree their hemolytic action. In blood serum, sodium chloride in a strength of 1–12, lithium chloride in 1–500, and calcium chloride in 1–50 show a definite antiseptic action toward the anthrax bacillus. Strong solutions of the salts are as a rule disinfectant only after long periods of time. Salufer, sodium hydrofluosilicate, has no bactericidal action. Most of the neutral salts have been classed as weakly or very feebly antiseptic.

Acids.—Here again, with certain exceptions, the disinfecting power seems to depend upon the degree of dissociation. Osmic, hydrofluoric, nitric, chromic, and trichloracetic acids have a specific action so that their germicidal value is greater than their degree of dissociation would lead one to expect. Other acids have been arranged in the following order of strength beginning with the strongest: perchloric, hydrobromic, acetic, hydrochloric, oxalic, hydrofluosilicic, and sulphuric. They are all sporicidal in normal solutions in from five to eight hours. The weaker acids such as phosphoric, formic, and boric have much less value. Solutions of boric acid, in fact, have to be sterilized by heat before their sterility can be assured. Crude sulphuric acid is quite strongly disinfectant and when mixed with crude phenol it becomes very powerful. It is of course very destructive.

Oxidizing Substances.—These may be arranged in the following order of strength: permanganic, persulphuric, chloric, dichromic, and nitric acids. Of the salts of these acids, practically the most important is potassium permanganate which in four per cent. solution will kill anthrax spores in fifteen minutes. The persulphates are powerful and not very poisonous. Wacker found that a one per cent. solution of ammonium persulphate was three times as powerful as carbolic acid.

*Peroxides.*—Hydrogen peroxide is a safe and powerful disinfectant. The commercial solution containing three per cent. of the chemical kills anthrax spores in about one hour. A ten per cent. solution is about equal to a 1–100 solution of mercury bichloride and is not poisonous. It may be used for the disinfection of drinking water though rather expensive if used for the ideal disinfectant except in the one item of cost. Perhydrol, hyperol, pergenol, and oxone are some of the names under which it is marketed. In various combinations as peroxol, naphthoxol, and camphoroxol it is united with other disinfectants. Other peroxides are used chiefly in forms which yield their oxygen slowly to the tissues and therefore are adaptable for dressings. Sodium peroxide, diacetyl peroxide, and benzoylacetyl peroxide, acetozone, are some of these products which gradually decompose in water.

Halogens.—Chlorine in watery solution is the most powerful of the known disinfectants. A 1–1,000 solution will kill anthrax spores in a few seconds. Bromine is only slightly weaker while iodine is markedly so. They all attack organic materials and therefore their practical use is somewhat limited. Since chlorine is much more active in a nascent state it is always desirable to have fresh solutions. A convenient way to attain this end is by a mixture of one per cent. potassium permanganate with 0.9 per cent. hydrochloric acid. Such a solution has a disinfectant power which is not reached by a five per cent. solution of corrosive sublimate. Iodine in alcoholic solution as the U. S. P. tincture will kill anthrax spores in one minute. A 0.25 per cent. solution is a safe disinfectant for staphylococci. It is rather extensively used

for the disinfection of the skin preparatory to surgical operations.

*Chloride of Lime.*—Bleaching powder is a mixture of calcium hypochlorite, calcium chloride, and calcium hydrate. It is an efficient disinfectant and has become very popular as a deodorant which, it must be remembered, is not at all the same thing. Contrary to the general belief, its action is one of oxidation and not of chlorination, the active ingredient being the hypochlorite. A 1–800 solution of chloride of lime killed typhoid bacilli in one minute and a one per cent. solution killed anthrax spores in twenty minutes. Tested upon pure cultures of the typhoid bacillus, its strength was thirty-five times that of phenol in killing the organisms in ten minutes. When added to sewage in a proportion of 1–25,000 it brought about a reduction of over ninety-nine per cent. in the number of organisms present. When added to water supplies in a proportion of from three to twenty-five pounds to a million gallons of water according to the conditions present, it practically assured its safety without disturbing its taste. It is being used very widely in this application to drinking water.

*Iodine trichloride* is very powerful, a one per cent. solution killing anthrax spores almost instantly. It is only slightly weaker in the presence of organic matter. Iodone, the periodide of phthalic acid anhydride liberates iodine slowly and is therefore more nearly allied to iodoform.

Aliphatic Carbon Compounds.—The hydrocarbons as a rule show no germicidal power.

*Alcohol.*—The bactericidal power of ethyl alcohol has been the subject of a great deal of controversy but it seems now to be fairly generally accepted that the seventy per cent. solution has the highest value. Absolute alcohol has practically no value. Its action is merely a dehydrating one and in addition is limited by the precipitate it forms in contact with proteins. The antiseptic action of alcohol is quite marked being first noticed in a 0.1 per cent. solution. Spores are not killed by any strength at the ordinary temperatures. The practical value of seventy per cent. alcohol is said to lie somewhere between that of 1–1,000 mercury bichloride and three per cent. phenol. The action of the higher alcohols is limited by the fact that they are for the most part insoluble in water. The official tincture of green soap owes its germicidal effect both to the soap and to the alcohol it contains. Pyogenic cocci are killed by it in from two to five minutes. Alcoholic solutions are frequently valuable for skin disinfection since they dissolve out the oils of the skin which serve as protection to the bacteria.

*Acetone* and *ether* have killed anthrax spores in from five to eight days. *Sodium lygosinate*, a sodium salt of dioxydibenzalacetone, is said to be slightly weaker than silver nitrate but not irritating.

*Formaldehyde.*—Formaldehyde has attained great popularity as a disinfectant during the past few years. It is on the market in the form of a forty per cent. aqueous solution of the gas which is universally known as formalin though the name is a registered one and properly should be applied only to the product of one manufacturer. It will be convenient to refer to the strength of this forty per cent. solution rather than to the per cent. of the gas in the figures given here. It is antiseptic in broth in a dilution of 1–50,000 and completely so in a dilution of 1–12,000. In contrast to this very marked antiseptic power its bactericidal action is relatively weak. Five per cent. formalin kills the *Staphylococcus aureus* in broth in thirty-five minutes. Its action is enhanced by the application of heat but even the use of ten per cent. formalin at a temperature of 38° will not assure sterility in five minutes. Its action is not improved by the addition of neutral salts and it is wholly neutralized in the presence of ammonia. Formaldehyde and ammonia unite to form a compound called hexamethylenamine and which is on the market under many names such as urotropin, formin, aminoform, etc. Helmitol, saliformin, and tannopin are compounds of this with other radicals. Hexamethylenamine breaks down in the body and formaldehyde is set free. This decomposition seems to take place with the greatest facility on the surface or in the substance of the serous and mucous membranes. For this reason this drug has been of great value in the treatment of infections of these membranes. Under certain circumstances formaldehyde polymerizes to form trioxymethylen, paraformaldehyde. Paraform is a white powder which slowly decomposes yielding formaldehyde. In itself it has no bactericidal action but it makes a good dressing for foul ulcers and is said not to be irritating. Formaldehyde has been combined with a number of other substances with the idea of getting a compound that will liberate the gas slowly. Some of these are gelatin and formaldehyde, glutol, ichthoform where it is combined with ichthyol, and tannoform in which tannin is present. Anios is formaldehyde with phenol. Lysoform is an alcoholic soap solution containing formaldehyde. In one per cent. solution it kills the typhoid bacillus in three hours and its three per cent. solution is about equal to a five per cent. solution of phenol. Formisol, baktoform, parisol, xyol and melioform are similar products. Festoform is a solid in which a hard soap is used. These soap preparations all have approximately the same value as lysoform.

*Acrolein*, allyl aldehyde, has a disinfectant power closely approaching that of formaldehyde but it is much more poisonous.

*Chloroform* has a rather important position among the halogen substitution products of the hydrocarbons. It has been disputed whether it is ever an actively bactericidal substance, the argument being that it acts by permitting autolysis. It has no effect upon anthrax spores even after long exposure. It has, however, a relatively great antiseptic action and such organisms as the cholera vibrio die in a short time in saturated chloroform water. It has been recommended for the sterilization of albuminous fluids such as blood serum in which it is claimed that the presence of chloroform in one to two per cent. strength is sufficient to warrant sterility. It can be driven off from the fluid by moderate heat and the fluid may afterward be used for culture media.

*Chloral hydrate* in twenty per cent. solution kills micrococci in two hours. A one per cent. solution is quite actively antiseptic.

*Iodoform.*—This powder with its exceedingly unpleasant odor has been used extensively as a surgical dressing. It is rather surprising that its germicidal power is very slight so that it is necessary to sterilize the powder before using it. Its action has been found to depend upon the fact that under the influence of wound secretions it decomposes and sets free iodine which is the active agent. Numerous similar substances have been brought forward as substitutes for iodoform under the plea that they too split off iodine and are not as toxic or unpleasant as iodoform. Iodoformine, its compound with hexamethylamine, and iodoformal, in which it exists in combination with ethyl iodide are neither of them odorless. Other similar combinations are dithymol iodide, aristol, europhen, sanoform, loretin, nosophen, antinosin, iodol, and thiophendiiodide. A number of compounds with bismuth are usually included here. Their bactericidal power is somewhat less but they are usually satisfactory substances for dressings. A few of them are airol, dermatol, vioform, xeroform, and orphol.

Carbocyclic Compounds.—*Phenol.*—Carbolic acid is most extensively used. It is more expensive than corrosive sublimate and is more poisonous on the skin. A five per cent. solution is somewhat stronger than a

1–1,000 bichloride solution and will produce anesthesia and gangrene if applied to the skin for any length of time. Its molecule is very stabile and the few compounds which it forms with acids and alkalis are in themselves disinfectant. It is not dissociated in solution and its action is therefore that of the molecule. The red color which develops when phenol is exposed to the light has no influence upon its disinfectant strength. An antiseptic effect is first noticed when phenol is present in the proportion of 1–1,250 and is complete in a strength of 1–850. Vegetative forms are killed by three per cent. solutions in a few seconds. At the usual temperatures anthrax spores are not killed even after many days by a seven per cent. solution which is the saturated aqueous solution. Such a solution will kill some spores, however, after twenty-four hours and is stronger than the liquefied phenol which contains about ninety per cent. carbolic acid. This is due apparently to the very low water content of the latter and is analogous to the action of absolute alcohol. When mixed with alcohol it completely loses its germicidal power and it is very markedly weakened when in solution in oils. On the other hand its action is favored by the addition of hydrochloric acid, tartaric acid, and neutral salts.

Cresols.—The ortho-, meta-, and paracresols are used either singly or as tricresol in which the three are mixed. They are present in crude carbolic acid which is a very cheap and powerful disinfectant. The cresols are all only slightly soluble in water and their germicidal value is higher than that of phenol. A mixture of equal parts crude carbolic and crude sulphuric acids produces a thick syrupy liquid which is easily soluble in water and is a very powerful disinfectant. The comparative strengths may be seen in the fact that seven per cent. phenol does not kill anthrax spores in forty days, a five per cent. solution of ortho-sulphonic or para-sulphonic acid kills them in from three to twelve days while a 0.3 per cent. solution of tricresol will kill them in from eight to twenty hours. The power of the cresols can be increased by the introduction of the halogens, especially chlorine, and chlormetacresol is an exceedingly powerful disinfectant. The toxicity also can be reduced by shifting these groups about, and recently Ehrlich has produced a compound called hexabromdioxydiphenylcarbinol which is about 250 times as powerful as phenol and is practically non-poisonous.

A very popular form in which the cresols are marketed is in the form of alkaline solutions in soaps. The best known of these preparations are *lysol* and *creolin*. Lysol is made up with a soft soap and makes clear solutions in water while creolin is made up with a hard soap and forms milky emulsions. These preparations are not injurious to materials and in the dilutions ordinarily used do not harm the hands. Among the better-known creolin preparations are creolin Pearson, creolin Austria, creolin Artmann, Jeyes' fluid and izal. They run from twenty-seven to fifty per cent. cresol, lysol having the latter percentage. The percentage of inert hydrocarbons differs widely in the different preparations. The disinfectant values of phenol, cresol, and creolin are in the proportion 1 : 3.5 : 10. The strength of creolin is much weakened in albuminous fluids being fifty times less in serum than in broth. Anthrax spores are not killed by pure creolin even after five weeks' exposure. Lysol is more powerful. In 0.3 per cent. solution the pyogenic cocci are killed in broth in thirty minutes, anthrax spores are killed in 0.5 per cent. lysol only after eight days. This effect is greatly increased by heat so that at 55°C. a ten per cent. solution kills all spores in five minutes. The value of lysol is also diminished in albuminous fluids but not to the same extent as that of creolin. As its solution has lubricating properties it is much in favor in obstetrical practice. The lysol- and creolin-like disinfectants which have appeared are almost numberless. A few of them are kresolin, bacillol, cresapol, CN, and phenolin. They can frequently be recognized by the formation of their names. Most of them are good germicides. Kresamine is made of equal parts tricresol and ethylendiamin. A two per cent. solution kills anthrax spores in water in two days but when suspended in blood serum, not even after six weeks. A solution prepared by the aid of heat of six per cent. soft soap and five per cent. crude carbolic acid is very cheap and useful. A one and one-half per cent. solution kills the vegetative forms of bacteria in thirty minutes and anthrax spores are killed by a five per cent. solution in six hours at 50°.

The cresols present in crude carbolic acid may be brought into solution by the addition of certain of the neutral salts. At first sodium salicylate and the salts of the orthoxybenzoic acids were used. Sodium cresolinate, however, has been found to be the best of these salts and solveol is a mixture of the three cresols with this salt. It contains about twenty-four per cent. of cresols, about half the percentage of the cresols in lysol, and its disinfectant power is somewhat less than that of lysol when based upon a similar cresol content. Solutol contains sixty per cent. cresols. Saprol and anthrasol are mixtures with mineral oil and coal tar respectively. Their values are those of cresol solutions of corresponding strength.

*Ichthyol.*—Ichthyol is a sulphur-containing compound which is distilled from a bituminous shale which includes many fossil fish. A five per cent. solution kills vegetative forms of bacteria in five minutes. Ichthalbin, ichthermol, ichthoform, anytin, and ichthargan are compounds in which ichthyol is united with other substances. They show a certain amount of elective affinity in that typhoid and cholera bacilli are only moderately affected while streptococci and diphtheria and anthrax bacilli are strongly attacked.

*Aniline* has a certain antiseptic value which is complete when aniline water is added to media in the proportion of one to five (about 1–160 of aniline). Acetanilide has but little antiseptic and no bactericidal action.

Of the substitution products of the phenols many are of more or less value in special conditions. *Parachlorphenol* is recommended in two per cent. solution for sputum disinfection. *Trinitrophenol*, picric acid, is antiseptic in a dilution of one part in two thousand and its one per cent. solution is germicidal. *Pyrocatechin, resorcin,* and *hydrochinon* are completely antiseptic in one per cent. solutions. *Pyrocatechin ethyl ether*, under the names thenatol, guathol, and ajakol kills vegetative forms in 1–1,000 solution. *Creosote*, which is a varying mixture of guaiacol and cresol, kills spore-free bacilli in two minutes in 0.3 per cent. solution. *Guaiacol* has a disinfecting power which ranks it with phenol and cresol. Its power is increased by the addition of alcohol to the extent of thirty-three per cent. There are numerous proprietary preparations which are compounds or derivatives of guaiacol and which have very variable disinfectant values.

*Benzoic acid* is antiseptic in a 1–1,000, solution. Anthrax spores are uninfluenced even after long periods of time. Among its homologues, phenylacetic, phenylpropionic, and phenylbutyric acids, the disinfectant power increases with the molecular weight.

*Salicylic Acid.*—Orthobenzoic or salicylic acid is antiseptic in 1–1,000 solutions but has very little bactericidal strength. It has no action upon spores. Phenyl salicylate, or salol, and acetylparamidophenol salicylate, or salophen, split off phenol in the alimentary canal and have therefore been recommended as intestinal disinfectants. The benzoates and salicylates have been used extensively in the preservation of food stuffs because of their relatively great effect upon the putrefactive bacteria. It is still undecided whether their prolonged use has any ill effects upon man. The best sustained objection to their use seems

to be that if such preservatives are employed an inferior quality of raw material may be utilized in the manufacture of certain food products.

The naphthalin group shows energetic disinfecting powers. Naphthalin itself is stronger than phenol. Alpha and beta naphthol limit the growth of the cholera bacillus in solutions of 1–16,000 and kill that organism in a dilution of 1–2,000 in fifteen minutes. The aluminum salt of naphtholsulphonic acid, alumnol, is antiseptic in a 1–250 solution. Thymol is a powerful disinfectant. A 1–1,000 solution at body temperature kills the pyogenic cocci in fifteen minutes. It has recently come into use in the form of a more concentrated solution in alcohol as a method for the disinfection of the skin preparatory to surgical operations. It is said to be quite as effective as the tincture of iodine for that purpose. Oil of turpentine is said to show a recognizable antiseptic action in dilutions as high as 1–75,000. Anthrax spores are killed in pure turpentine in five days. Its strength is greatly diminished in gelatin. Camphor and menthol are antiseptic in 1–500 solutions. The action of camphor is greatly aided by the presence of heat.

Alkaloids.—*Chinolin* is antiseptic in 1–500 solution and chinolin sulphocyanid is still more powerful. *Chinosol*, an oxychinolin derivative, kills pus cocci in 1–1,000 solution in fifteen minutes. *Diaphtherin*, a combination of oxychinolin with orthophenolsulphonic acid is a strong antiseptic. The following substances are antiseptic to the staphylococcus in the strengths named; kairin 1–400, thallin 1–1,100, quinine hydrochloride 1–550, morphine hydrochloride 1–50, antipyrine 1–25. Antipyrine kills diphtheria bacilli in a five per cent. solution in twenty-four hours. It should be noted that the action of quinine is much stronger against the protozoa than the bacteria. Its destructive action upon the plasmodium of malaria is well known and it is a valuable aid in the eradication of the pathogenic amebæ.

Organic Coloring Matters.—In the consideration of these dyes it is interesting to note that the group which unites the dye to the bacteria and that which gives it its bactericidal action is entirely separate and distinct from the one which gives the substance its color. Malachite green is antiseptic in blood serum in a strength of 1–40,000; methyl violet or pyoktanin in 1–10,000. Yellow pyoktanin, auramin, first shows antiseptic action in a one per cent. solution. The antiseptic action depends upon the structure of the subtance and especially the character of the aromatic nucleus. In many instances they exhibit a certain amount of elective affinity. For example, the action of malachite green upon anthrax and cholera is about 100 times as strong as its action upon the typhoid bacillus.

Ethereal Oils.—Certain of the ethereal oils have a strong bactericidal action approaching in strength that of a 1–1,000 bichloride solution. Oil of mustard prevents the growth of anthrax in a dilution of 1–33,000. Garlic juice in two per cent. solution kills cholera bacilli in two minutes. The oil of Ceylon cinnamon kills vegetative forms in twelve minutes and even in blood serum its antiseptic action is about three times that of phenol. The oils of rosemary, lavender, and eucalyptus act only in substance and not in solution. Cinnamon, origanum, fennel, lavender, and clove oils are energetically bactericidal in the form of vapor. Tobacco smoke is antiseptic to many organisms especially the cholera bacillus and the bacillus of Friedlander. It does not depend for its value upon the nicotine content since this alkaloid is not antiseptic even in one-half per cent. solution. The presence of the pyridine bases probably explains its action since they are possessed of penetrating power and would kill these organisms. The vapor from roasting coffee has some bactericidal action and a ten per cent. infusion of coffee will kill the cholera bacillus in three hours and pyogenic cocci in six days.

Animal Extracts.—The only well-defined chemical substance obtained from animal organs which has antibacterial action is nucleic acid. Of this a one-half per cent. solution kills cholera bacilli in from three to five minutes, typhoid bacilli is one and one-half hours, and the pus cocci in six hours. Anthrax spores are unaffected after twenty-four hours. The effect depends upon the ability of nucleic acid to precipitate albumin.

Gaseous Disinfectants.—It has been found necessary to treat of these substances in a separate paragraph since the action of the gas in most instances exhibits a certain amount of difference from the action of a solution of the substance. In practical disinfection also they constitute a separate class of substances which are used for a definite purpose. The claim has been made that a solution and a vapor of a volatile organic compound with equal partial pressures of the essential material have equal antiseptic powers, except when some union takes place with the medium. This dictum, however, is not well substantiated as yet and further proof must be advanced. Among the general principles of the use of gaseous disinfectants the most important one is that they will have no action upon dried bacteria. Here, as indeed under all other conditions, the presence of an abundance of moisture is essential to the most powerful action of the disinfecting agent.

*Oxygen* has a distinctly injurious action upon anaerobic bacteria and when under a certain amount of pressure even upon some aerobes. Nascent oxygen and ozone are included among the oxidizing agents and possess germicidal properties. Pure carbon dioxide is antiseptic to a slight extent but even when under pressure its action is not dependable. *Illuminating gas* injures most pathogenic organisms but has no influence upon the putrefactive ones. *Nitrous oxide* is able to kill the cholera bacillus and the pyocyaneus. *Hydrogen sulphide* and *hydrofluoric acid* have practically no action and *ammonia gas* has very little. The vapor of boiling ninety to ninety-five per cent. alcohol has very little germicidal effect. That of fifty per cent. alcohol is approximately that of streaming steam. The vapor from boiling seventy-five to ninety-nine per cent. *acetic acid* is very powerful, killing anthrax spores in about five minutes. The practical value of these substances is slight.

*Sulphur Dioxide.*—When tested in a small box sulphur dioxide in a concentration of 0.5–0.8 volumes per cent. has killed spore-free bacteria in twenty-four hours. Chlorine acts similarly in a strength of 0.2–0.3 volumes per cent. In larger spaces, however, the results are less sure partly because it is not possible entirely to prevent leakage and partly because it is not possible to obtain a good mixture of the gas with the air of the room. Also when the requisite amount of moisture is present in order to assure germicidal action these gases are very destructive. The sublimation of bichloride is impractical since it solidifies much too quickly and at too high a temperature.

*Formaldehyde Gas.*—By far the most important and efficient of the gaseous disinfectants is formaldehyde gas. Like all of this class it is merely a surface disinfectant and demands abundant moisture for its action. Nevertheless, it does act powerfully and rapidly and is but slightly injurious to materials. When the apparatus used is in working order and all the conditions are right the disinfection obtained is very complete. The action is strengthened if the air can be removed from the space before the admission of the gas. It is rather curious that this vapor, which is so intensely poisonous to the bacteria and so very irritating to the mucous membranes of man, is not at all an insecticide. Vermin are apparently not affected and even larger animals such as guinea-pigs

have spent hours in a room that was being disinfected without suffering harm.

TABLE I.—RIDEAL'S TABLE OF GERMICIDAL POWERS OBTAINED BY MEANS OF THE RIDEAL-WALKER METHOD AND CALCULATED TO CARBOLIC ACID AS 1.00.

| | |
|---|---|
| Carbolic acid | 1.00 |
| Chlorine water | 28.00 |
| Copper sulphate | 2.00 |
| Formaldehyde | 0 70 |
| Hypochlorites | 146.00 |
| Iodine water | 100.00 |
| Hypochlorites (50 per cent. urine) | 8.00 |
| Silver nitrate | 15.80 |
| Iodine trichloride | 94.00 |
| Chinosol | 30.30 |
| Mercury bichloride | 400.00 |
| Boric acid, less than | 0.10 |
| Potassium permanganate | 42 00 |
| Hydrochloric acid | 1.58 |
| Eucalyptol | 1.20 |
| Zinc chloride | 0.15 |

TABLE II.—HYGIENIC LABORATORY PHENOL COEFFICIENT DETERMINED BY ANDERSON AND MCCLINTIC FOR A NUMBER OF PREPARATIONS NOW ON THE MARKET TOGETHER WITH THE TOXICITY AS DETERMINED BY HALE, BOTH REFERRED TO CARBOLIC ACID AS 1.00.

| Disinfectant. | Phenol coefficient. | | Toxicity. |
|---|---|---|---|
| | With organic matter. | Without organic matter. | |
| Bacterol | 1.34 | 1.58 | 0 45 |
| Benetol | 0.92 | 1.23 | 0.33 |
| Sulphonaphthol | 2.33 | 3.87 | 0.11 |
| Carbolene | 0.65 | 1.36 | 0.11 |
| Carbolozone | 0.48 | 1.48 | 0.064 |
| Car-sul | 1.75 | 2.00 | 0.16 |
| Chloronaphtholeum | 3.21 | 6.06 | 0.16 |
| Cremolin | 0.69 | 1.26 | |
| Creo-carbolin | 2.26 | 4.03 | 0 30 |
| Creolin Pearson | 2.52 | 3.25 | 0.18 |
| Cresoleum | 1.75 | 2.90 | 0.11 |
| Crude carbolic | 2.63 | 2.75 | |
| Creoleum (Dusenberry) | 0.40 | 1.00 | 0.09 |
| Germol | 1.79 | 2.12 | 0.16 |
| Hycol | 9.37 | 12.30 | 0.32 |
| Hygeno A | 1.81 | 3.56 | 0.17 |
| Kreosota | 0.65 | 1.26 | 0.056 |
| Kreotas | 0.30 | 1.10 | 0.056 |
| Kreso | 2.32 | 3.92 | 0.225 |
| Kresolig | 1.48 | 2.18 | 0.56 |
| Lincoln disinfectant | 1.10 | 1.48 | 0.17 |
| Liquor cresolis comp. U.S.P. | 1.87 | 3.00 | 0.56 |
| Lysol | 1.57 | 2.12 | 0.45 |
| Naphthalene | 1.36 | 2.50 | 0.075 |
| Phenoco | 9.86 | 15.00 | 0.32 |
| Phenol liq. U. S. P. 1890 | 1.76 | 1.77 | ... |
| Phenoso'e | 2.31 | 3.43 | ..... |
| Phinotas | 0.53 | 1.37 | 0.09 |
| R. R. Rogers disin | 2.05 | 3.03 | 0 56 |
| Rudisch's creolol | 0.75 | 1.24 | 0.13 |
| Saponified cresol | 0.57 | 1.03 | 0.064 |
| Tarola | 1.93 | 3.12 | 0.16 |
| Trikresol | 2.50 | 2 62 | 0.90 |
| Zenoleum | 1.64 | 2.25 | 0.19 |
| Zodone No. 4 | 0.51 | 1.62 | 0.086 |
| Zonol | 1.57 | 2.37 | 0.10 |

TABLE III.

Also obtained by Anderson and McClintic but the substances were so weak that no attempt was made to determine their coefficient in the presence of organic matter.

| | |
|---|---|
| Acetozone | no death in 15 minutes. |
| Creola disinfectant | 0.52 |
| Dioxygen | ? 20 per cent. killed in 5 minutes. |
| Electrozone | 0.90 |
| Formacone liquid | ? 5 per cent. did not kill in 15 minutes. |
| Killitol | 50 per cent. did not kill in 15 minutes. |
| Kretol | 0.92 |
| Listerine | 20 per cent. did not kill in 15 minutes. |
| Phenol sodique | 20 per cent. did not kill in 15 minutes. |
| Pino lyptol | 0.27 |
| Platt's chlorides | full strength took 10 minutes to kill. |
| Sanitas | 0.30 |
| Veroform germicide | 0.43 |
| Zodone, No. 3 | ? 20 per cent. killed in 7½ minutes |

RALPH G. STILLMAN

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**Disinfection.**—Preventive measures in some form have always been employed as a barrier against disease and it is interesting to follow the progress made in this direction which is quite clearly described in the medical literature of the past as well as of the present. From a practical standpoint the subject may be best dealt with under three different periods.

The first relates to the various preventive measures described in the earliest history to the discoveries of Pasteur and Koch, about thirty years ago, and which for the first time gave to the world definite and conclusive evidence of the germ origin of infectious diseases and established sanitation upon a scientific basis.

The decade which followed may be regarded as the second epoch and includes a period of great activity in the laboratory, for the researches of Pasteur and Koch led to extended bacteriological investigation throughout the world and the identification of many pathogenic organisms.

The third and most important period refers to the past fifteen or twenty years, for during this time the knowledge previously gained regarding the prevention of disease has been carefully adjusted and we are now

familiar with the true means by which many of the infectious diseases are transmitted, and the methods which have been successfully employed to prevent their extension.

With the exception of cleanliness, which in some parts of the world was early recognized as a valuable means of protection against disease, the preventive measures first recorded were not only crude and of little or no value, but their employment was often dangerous to life and destructive to property; furthermore there is abundant evidence that these methods were not confined to the very earliest times, for instance it is recorded that as late as the eighteenth century, vessels coming from presumably infected ports were by official order sunk at sea to prevent the transmission of disease through the medium of their cargo. Although these unreasonable measures became less common as years went by, in a way they have continued until recent times. Of this abundant proof is presented, for instance during the Spanish War iron rails were disinfected in the Southern States to prevent the transmission of yellow fever, and for the same reason vessels were so drastically treated by disinfection that their cargoes were oftentimes seriously injured or practically destroyed.

It is not difficult to find a satisfactory explanation for these destructive and unjustifiable measures, for previous to the last half century they were commonly directed not by the result of scientific investigation, but largely by the theories of those who at the time happened to be in charge of public health matters.

While it is true that prior to the time of Pasteur and Koch valuable information relative to the origin of disease had been obtained by the microscope, it was chiefly the work of these savants that led more directly to our present satisfactory knowledge of this subject. Activity in this direction naturally led to the investigation of disinfectants, for it was then believed that the prevention of infectious diseases depended largely upon the treatment of apartments, clothing, baggage, cargoes of vessels, etc. As a result the laboratories produced innumerable germicidal agents. Interest in this subject also extended to the public, for so-called disinfectants were soon placed on sale in the shops and guaranteed to protect against all forms of infection.

Thus it will be seen that so far as preventive measures are concerned, the first period was one of ignorance and chaos, and although later the foundation was laid for the scientific and practical investigation of this subject, it was left for the last and most important period to bring together the evidence of bacteriologists and the experience of practical sanitarians who have been long engaged in field work, and have had an opportunity to deal with matters pertaining to the public health upon a broader basis than comes within the province of the bacteriologist.

The result has been, we have learned, that many of our theories regarding the means by which infectious diseases are transmitted are erroneous, for conclusive evidence has been presented that infection is transmitted by persons rather than things, either directly from one to another or through the medium of food and drink, or insects and vermin. The importance of this knowledge cannot be overestimated, for it has placed in our hands means by which outbreaks of infectious diseases may be successfully dealt with, and the ravages which they have caused in the past need never occur again if proper sanitary methods are employed.

The factor which more than any other has militated against an earlier recognition of the true means by which infectious diseases are transmitted has been the so-called fomites theory which holds that clothing, baggage, money, furniture, cargoes of vessels, etc., commonly transmit infectious organisms in their active state from one person to another. Unbounded faith in this belief has been maintained until recent years when the fallacy of the theory has been exposed and it has been shown how little practical and scientific evidence there is to support it.

In one form or another the fomites theory has probably always existed and the literature of the past frequently alludes to it, during the fourteenth century, when marine quarantine was first established cargoes of vessels arriving from foreign ports were often spread about the deck and exposed to the sun and air for so-called "purification," although in the meantime it is quite likely that members of the crew of the vessel, the real media of infection, were allowed to visit the shore. In a way this has its parallel even at the present time, for in the care of infectious diseases it is commonly believed that one of the most important preventive measures is the so-called terminal disinfection or the treatment of the apartment at the conclusion of the case, whereas the discharges from the patient, which constitute the most dangerous source of infection and which should be promptly destroyed, are often carelessly dealt with. Therefore the fomites theory has diverted our mind from the true means of infection and in this way has contributed largely to the extension of disease. The chief support of this theory lies in the fact that it offers a plausible explanation for outbreaks of infectious disease the true origin of which is unknown.

Previous to 1898 it was generally believed that yellow fever was commonly transmitted by fomites, and the medical history of the South is rich in confirmation of this, yet the investigation conducted in Cuba by the United States Government entirely shattered this theory and presented indisputable evidence that yellow fever is transmitted by the mosquito, and so far as we know at the present time in no other way.

Satisfactory proof has also been presented that plague is transmitted, not by fomites as it was formerly supposed, but by the flea which infests the rat, and more recently the greatest blow of all has been given this theory, for evidence which at present seems to be conclusive indicates that typhus fever, which heretofore has been regarded as one of the most infectious diseases and generally believed to be transmitted chiefly by fomites, is conveyed from one person to another by the body louse. Therefore clothing, bedding, and other textile fabrics connected with the patient take no part in the transmission of these diseases beyond harboring the insect.

The fomites theory has been responsible for regulations which call for the most drastic treatment in the way of disinfection of apartments, schoolhouses, public buildings, public conveyances, vessels, etc., not only where infectious diseases are known to have existed, but as a general preventive measure. Even if disinfection was called for in these instances the means usually employed are frequently of little or no value.

It is also a common belief that alleged infected material such as clothing, toys, etc., which have been laid away for months or even years may transmit disease when again exposed. Statements to this effect, which are often quite plausible, are usually presented by members of the family where the disease occurred, and the busy physician has but little or no opportunity to carefully investigate the evidence. A consideration of this part of the subject will show that these statements have little or no scientific value unless the possibility of infection through mild or unrecognized cases or carriers can reasonably be excluded, for the latter is usually the true explanation of this condition.

My personal investigation in Egypt, relative to the danger of the transmission of disease by rags, presents satisfactory proof that infection is not conveyed through this source. This may also be said regarding the alleged danger of money as a medium of infection, for careful investigation has also shown that there is but little danger of infection from this source. It is true that in rare instances the various articles above

referred to may transmit infection, but abundant evidence has been presented to show that they are unimportant factors in the transmission of disease.

Modern investigation has shown the great value of practical experience in determining the means by which infection is transmitted, for laboratory investigation considered alone is very apt to favor the fomites theory, and also the belief that where infectious diseases have occurred organisms in their active state may be found almost everywhere about the apartment. The truth is that diseases are not conveyed through these sources except in some unusual instance, and it should be remembered that practical and reasonable sanitary measures do not guarantee absolute safety, and while proper efforts should be made to secure all possible protection, it is the common and not the rare means of infection that must command our special attention.

The aerial theory of the transmission of disease has as little scientific evidence to support it as the fomites theory, and it is almost as popular as the latter; for this too is a plausible explanation of outbreaks of infectious disease and also discourages more exhaustive investigation to ascertain the true sources of infection. Medical literature contains innumerable statistics which are intended to prove that infection travels through the air over long distances, even a mile or more. Satisfactory or even reasonable evidence is wanting to confirm this theory and it is now practically discarded, besides these theories are not now required to explain outbreaks of infectious disease, for the real means by which many of them are transmitted is now fully understood.

Another theory which may be noticed in connection with this subject, and one which will likely share the fate of those just referred to, is the belief that the desquamation of scarlet fever and measles constitutes a common medium of infection. Desquamation occurs in sunburn and in many other conditions where the functions and nourishment of the skin has also been seriously and suddenly interfered with. Aside from the fact that it is always present in the diseases just referred to, there is no scientific proof that it transmits disease from one person to another, and there is good reason to believe that it will sooner or later be found to be a negligible factor as a conveyor of infection.

So far as disinfection is concerned we have come to the parting of the way and we must either hold to the theories just referred to and allow them to dominate disinfection as they have in the past, or discard them and accept the knowledge which modern scientific investigation has presented and which calls for disinfection only when the employment of this preventive measure is justifiable and called for.

We now know that infectious diseases are most commonly transmitted from one person to another by discharges, and that their prompt disinfection or destruction offers the greatest protection against infection. Danger from this source may be due to the direct transmission of the discharge from the sick to the well, or by the hands or infected articles of various kinds used about the patient, or by food or drink or insects.

In cholera and typhoid fever it is the discharge from the intestinal tract. In measles, diphtheria, and scarlet fever it is the discharges from the nose, throat, or ears, and in tuberculosis it is the sputum which contain the infectious organisms.

In smallpox it is quite true that the eruption contains the specific germ of the disease and through this means, at least in certain stages, infection is transmitted; however, reliable proof has been presented that persons unprotected by vaccination and who have lodged in rooms which within a short time previously had been occupied by advanced and well-marked cases of smallpox did not contract the disease, although no disinfection was performed. This has occurred so often that it would seem to indicate quite clearly that *it is the patient and not the apartment that is the source of infection.*

The belief that desquamation commonly transmits infection in scarlet fever and measles has overshowed the danger of the discharges in these diseases which are transmitted from one person to another by coughing and sneezing, by the hands particularly of the mother or nurse, who frequently constitute a medium of infection. When great care is taken, particularly in the form of cleanliness, infectious diseases may without danger be treated in adjoining apartments, with only a dwarf or half way up partition between them. It is quite certain that this result would not follow if diseases were transmitted by aerial infection.

The opinion of practical sanitarians of long experience is unfavorable to terminal disinfection, which is largely a creature of the fomites theory and refers to the treatment of an apartment at the termination of a case of infectious disease for the purpose of destroying actively infectious germs which are believed to be present in the furniture, hangings, cracks, etc. Careful observation and experience do not confirm this but rather prove that the apartment is an unimportant factor in the transmission of infection. This verdict may be regarded as the culmination of many years of experience and investigation on the part of those who have worked in the field and whose opinion is entitled to the most careful consideration.

The municipal health authorities of several cities in the United States have already practically discarded room disinfection, particularly in measles, scarlet fever, and diphtheria, and also in connection with other infectious diseases. This has been followed by very satisfactory results and the statistics already available show that where this course has been followed that in numerous instances a decrease rather than an increase in secondary cases has occurred, this is undoubtedly due to the fact that greater care has been taken in connection with the destruction of the discharges of the patient during the progress of the disease.

The belief that germs in their active state are lurking everywhere in an apartment, ready at any moment to transmit disease, has become so firmly imbedded in the minds of physicians as well as laymen that it is with great reluctance that terminal disinfection is discontinued.

It is true that there are instances where gross carelessness occurs in the treatment of infectious diseases and discharges are expelled everywhere about the apartment. It is possible under these extremely unsanitary conditions that infection may be transmitted through this source and that in these uncommon instances some form of disinfection is justified.

While it is the general practice to perform terminal disinfection in apartments where smallpox has occurred, it has not yet been determined how far it is necessary as a preventive measure.

Terminal disinfection is also generally employed in tuberculosis when a fatal termination occurs. This can hardly be deemed logical or consistent, for while Departments of Health throughout the country usually require disinfection where death has occurred in tuberculosis, practically no official action is taken in this direction if the patient recovers, although the danger remains the same during the course of the disease. Besides, public health officials have already expressed the opinion that with care a patient suffering from this disease may remain in the house with others without transmitting the disease. If this is true, and there is probably no doubt about it, it may be pertinently asked on what logical grounds is disinfection restricted to instances in which cases end fatally.

Terminal disinfection promotes carelessness in many ways, for those who believe in it are very apt to overlook the importance of dealing promptly and

effectively with the discharges of the patient during the course of the disease, believing that the treatment of the apartment at the termination of the case will go far to extend protection against the transmission of infection.

Aside from material actually worn or used in contact with those who are sick with infectious diseases, there is no justification for the disinfection of various articles such as clothing, baggage, cargoes of vessels, rags, money, etc., and until this opinion is accepted it is not likely that proper care will be taken in the disinfection of material or articles which are really media of infection.

It may very truthfully be said that if the disinfection of apartments, clothing, baggage, etc., was really necessary the manner in which it is commonly performed would offer but little protection, for this work is usually left in the hands of the family or those who are not practically familiar with the manner in which it should be employed. To properly perform disinfection special knowledge is required, and therefore it should be in the hands of those who are competent to deal with it.

If the fomites theory is discarded and the modern belief is accepted regarding the means by which infection is transmitted from one person to another, disinfection becomes necessarily restricted to within comparatively narrow limits.

The most important and necessary disinfection relates to the treatment of the person or the discharges of those who are sick with infectious disease, and the value of this depends largely upon the promptness with which the discharges are dealt with after their expulsion from the patient, rather than at regular intervals or along the lines of terminal disinfection. This same prompt action must also be followed in the destruction or disinfection of material or articles used about the patient, which are quite liable to be contaminated with the discharges.

There is probably no more dangerous or common source of infection than the hands, and it is through this means that diseases are commonly transmitted, but where cleanliness is strictly observed and the discharges are carefully disinfected there can be but little or no danger of room infection even if germs after leaving the body remain as active as some erroneously believe.

The disinfection of the apartment at the termination of a case of infectious disease is as a rule unnecessary or at least of secondary importance. It is still demanded particularly where smallpox has occurred, although, as it has already been stated, proof has been presented which indicate that persons unprotected by vaccination, or a previous attack of smallpox, have occupied rooms from which cases of this disease had just been removed, and where no disinfection had been performed, without becoming infected.

The disinfection of cargoes of vessels and the baggage of those coming from infected sections is unreasonable and uncalled for; besides, the means by which it is carried out is usually valueless and the expense and unnecessary loss of time to the public and commerce are incalculable.

There can be no doubt that the future will show that protection against the transmission of infectious diseases lies chiefly in the prompt destruction of the discharges of those who are ill, and the most careful observance of cleanliness, for the latter represents one of the most important factors in the prevention of disease.

In the consideration of the various germicidal agents we must first recognize the value of nature's disinfectants—fresh air and sunlight. Not to understand or to utilize the aid they extend means that our efforts to prevent or control infectious diseases will frequently meet with doubtful success. Of all that bacteriological research has taught us, nothing has been of more importance than the knowledge of their wonderful germicidal power. The disappearance of infectious diseases in communities where there are no organized modern means of combating this danger is largely due to sunlight and fresh air, which are always available and therefore can be brought in contact with specific germs. It has been proven that pathogenic organisms are sooner or later destroyed when exposed to sunlight and air. This fact carries with it great significance, as it places in our hands at all times a germicidal power which, although comparatively slow in action, if properly used, contributes largely toward protecting a community against infectious disease, and is particularly valuable when other means of disinfection are not at hand.

*Steam.*—Of the disinfectants which it is within our power to create steam and boiling water are by far the most valuable, for absolute dependence can be placed upon them if properly employed. Their action is quick and deep penetration is assured—the latter being a most important consideration. These invaluable qualifications are not possessed to the same extent by other disinfectants. The experiments made with steam some years ago under my direction showed that a moist temperature of 230° F., if continued for a period of fifteen minutes or even less, killed the bacilli of anthrax, bubonic plague, and diphtheria, when placed in the center of large bundles. Moreover, it was found that a moist temperature of 135° to 150° F., with an exposure of fifteen minutes, generally killed all organisms employed in the test except anthrax, when they were more directly exposed as in superficial disinfection, but not when placed in the interior of packages. In the experiments where a temperature of 230° F. was employed, the self-registering thermometer placed with the infected discs in the center of large bundles of clothing, bedding, and blankets showed but little or no diminution in the temperature at that point, whereas in tightly rolled and closed packages of newspaper, which resists penetration, the inside temperature sometimes showed a reduction of thirty or forty degrees; repeated tests showed that this result was uniform and that material usually presented for disinfection, such as clothing, bedding, etc., is easily penetrated by steam. The importance of this is evident, as in public or general disinfection it is impracticable to open and spread out all material received for disinfection, which requires great expenditure of time. The results of the experiments above referred to are in accord with those of other investigators, and it may be accepted that a temperature of 230° F., with an exposure of fifteen minutes, is destructive to all pathogenic organisms which may be present in bundles.

Although the ordinary cotton and woollen materials generally used in the manufacture of clothing, bedding, carpets, etc., are not injured by steam, it destroys articles made of rubber, leather, fur, material stiffened with glue, etc., and is apt to injure silks and satins and other delicate fabrics. In the modern method of steam disinfection, ordinary mail composed of letters and papers can be subjected to steam without injury or defacement of writing. Fortunately, however, modern sanitation does not regard this material as a menace to the public health, and the disinfection of mail has been abandoned.

The potency of steam as a disinfectant, its reliability for deep as well as superficial disinfection, and its rapidity of action, make it necessary that every community should be prepared to employ this agent although our present knowledge of the means by which infectious diseases are transmitted calls for far less disinfection than heretofore.

It would be of comparatively little interest to enter into a detailed account of the evolution of the steam disinfecting chamber, which has passed through many changes until it has now reached a stage where it seems to comply with modern scientific requirements. The disinfecting steam-chamber originally used was

faulty in many ways; not only considerable time was required in securing the necessary temperature, but at the termination of disinfection the means of releasing the steam from the chamber was very unsatisfactory, as were many other details connected with the working of the apparatus. The long time required to secure the proper temperature was due to the presence of air in the closed chamber; this is a bad conductor and is penetrated very slowly by the heat. Improvement has been made in this direction by the use of a vacuum apparatus which removes the greater portion of the air from the chamber before steam is allowed to enter, by which means the required degree of temperature may now be obtained in five or six minutes. The vacuum is also employed after disinfection is completed and before the door of the apparatus is opened, not only to remove the steam introduced into the chamber for disinfection, but also for the purpose of drying the material under treatment.

*Boiling water* has a more extended range of usefulness than steam and if properly employed is the most valuable and practical disinfectant that can be obtained. It costs nothing, its germicidal effect can always be depended upon, it acts quickly, is safe, and can always be obtained wherever a fire can be made and a proper receptacle is available. The great value of this is at once apparent for it means that under almost any circumstances we have at our command an agent which can always be relied upon for the prompt destruction of all infectious matter with which it comes in contact. This fact is becoming gradually understood and it will not be long until boiling water will replace other germicidal agents in the sick-room.

Some form of apparatus for boiling water may always be improvised, it is only needed that a metal receptacle be provided and the water may be heated either by an ordinary fire, oil lamp, or gas. A very effective and inexpensive apparatus for this purpose may be constructed as follows: A sheet copper receptacle sufficiently large to hold a full-sized bedpan, with some form of metal supports to raise it sufficiently above the ground to admit a lamp or gas apparatus for the purpose of obtaining heat. The cover should if possible be made heavy enough to offset a slight pressure of steam; this is, however, still further provided for by a spout which is attached to the portion of the top not involved in the cover and for the same purpose that a spout is used on a teakettle, to allow the escape of steam. The upper end of this should be connected with a flexible tube which in some way connects with the outer air in order that the steam does not escape into the apartment. The temperature of the water may be kept below the boiling-point, in instances where the apparatus is being more or less continuously used in the apartment of the sick. The addition of a small amount of permanganate of potassium to the water will usually prevent any unpleasant odor. The value of this method lies in the fact that when a bedpan, for instance, is brought from the patient, placed in the bath and exposed to boiling water for fifteen minutes we may be certain that both the receptacle and the discharge are disinfected and it makes no difference what is done with them afterward. This apparatus is only the suggestion of a principle which may be improved and carried out in a larger scale. Steam apparatus for this same purpose may be used in hospitals and other institutions with the most effective results.

Dry heat has little or no value in general disinfection, for its power of penetration is limited and the temperature necessary to disinfect clothing would be likely to injure or destroy this material, therefore this agent is limited rather to laboratory uses.

*Sulphur Dioxide.*—This gas, which is generated by burning common roll sulphur, is regarded as the oldest known disinfectant, properly it is the sulphurous acid gas which is formed by the combination of sulphur dioxide and the moisture of the air which disinfects. Under no conditions can this agent be depended upon for penetration and it is therefore suitable only for superficial disinfection; even this result will not be obtained unless some moisture is present. The full combustion of four pounds of sulphur for every 1,000 cubic feet of space with an exposure of six hours will probably secure the full germicidal value of this agent, provided the apartment is properly sealed. Theoretically it has been held that the volatilization of one pint of water at the time of the combustion of four pounds of sulphur produces sufficient moisture for the purpose. My investigation does not confirm this statement, but rather that many times this amount does not always obtain the desired result. In a general way it may be said that in the summer particularly when the humidity is high, the question of added moisture need not be considered, whereas when the apartments are closed and heated as in winter the evaporation of two quarts of water for each four pounds of sulphur should be provided for by boiling the water in a superficial metal receptacle over the burning sulphur about six inches above the flame. In the general use of sulphur for the treament of presumably infected apartments, but little thought or consideration is given these details, therefore if the disinfection of a room at the termination of a case of infectious disease were necessary, which, as a rule, it is not, the means which are usually employed would be of little or no value.

Sulphur is quite cheap and can be purchased for about three cents a pound, and an apparatus for burning it may easily be improvised in the following manner: Two or three bricks are laid in the bottom of an ordinary washtub; on these may be placed a tin pan or some other metallic receptacle for the sulphur. Water should be poured in the tub to a height just above the bricks and covering the bottom of the pan. This arrangement prevents danger from fire, which might occur if the pan containing the burning sulphur rested directly on the floor; it also protects the bottom of the pan. Apparatus which are constructed for the generation of sulphur dioxide usually follow the principle embodied in this simple arrangement.

In order to secure the full combustion of the sulphur, the latter must be broken into small pieces, over which alcohol should be freely applied. Methyl alcohol which is quite cheap may be used for this purpose. The alcohol should be lighted by a taper or a lighted match dropped into the mass, and the operator should be careful not to have his face too close to the pan. When thus treated complete combustion almost always occurs. Powdered sulphur should not be used, for satisfactory combustion cannot take place owing to the deficiency of air in the mass. It should be remembered that sulphur dioxide will bleach or otherwise injure or destroy gilded material, wall paper, silks, satin, and various other material.

*Formaldehyde Gas.*—During recent years formaldehyde gas has also been depended upon for the disinfection of apartments. In a commercial way this gas is obtained by the imperfect combustion of wood or methyl alcohol. Probably no disinfectant has been more exhaustively investigated than formaldehyde gas, and although many different methods have been suggested to secure its full germicidal value in a convenient and practical way, but two of these will be referred to, the Walker and the permanganate of potassium method.

The first is as follows for the disinfection of an apartment of 1,000 cubic feet: Saturated solution of aluminum sulphate, two ounces; forty per cent. formaldehyde solution, six ounces. These are to be mixed and poured over one pound of unslacked lime

contained in a metallic receptacle such as an ordinary tin pan. The formaldehyde gas which is evolved by this mixture is discharged in about fifteen minutes. Great care must be taken in selecting the lime, which as a test should slack rapidly in cold water. It should be broken into small pieces in order to secure prompt results. *If air-slacked lime is used the process is of no value.*

The permanganate of potassium method referred to is as follows: For an apartment of 1,000 cubic feet space, thirteen ounces of permanganate of potassium are added to two pints of a forty per cent. formaldehyde solution. Great care must be taken in preparing this mixture, which must be made in a large metallic pail to prevent the escape of the excessive foaming or overflow which occurs. The permanganate should first be placed in the pail and the formalin poured in afterward. The gas is generated at once, and for this reason arrangements must be made beforehand in order that the apartment may be quickly vacated. While this is a rapid and effective means of generating the gas, there are certain results which may occur and which must be carefully considered before this method is employed. The violent chemical reaction which takes place when the mixture is made is apt to cause combustion and the resulting flame may rise some distance above the receptacle and cause fire if an inflammable material is in the immediate vicinity. Furthermore, when this occurs the formaldehyde is rendered useless and no disinfection occurs. The gas burns with a pale blue flame, and is hardly noticeable during the day time, but is apparent in the dark. If no flame occurs it may be assumed that the gas is intact.

In using formaldehyde gas as a disinfectant an exposure of from four to six hours is sufficient.

Formaldehyde gas like sulphur dioxide is simply a superficial disinfectant and cannot be depended upon for penetration; however, there are differences to be noted in the two gases. Sulphur dioxide requires the presence of moisture, but it is probable that formaldehyde does not. Sulphur dioxide bleaches and otherwise injures various materials with which it comes in contact. This does not occur when formaldehyde is used. While neither of these gases is respirable by the human being, formaldehyde cannot be depended upon to kill vermin and insects; on the other hand they always quickly succumb to sulphur dioxide.

*Mercuric chloride*, also known as corrosive sublimate and bichloride of mercury, is a very valuable disinfectant for some purposes, as its germicidal action can be depended upon. It is a very violent poison and therefore hardly safe for general use. It is precipitated when in contact with albuminous matter and under these conditions its efficiency is weakened. It will permanently fix blood stains which may be found on garments or other material; this may be avoided if the spots are washed out before being treated with this agent. The use of bichloride of mercury has been restricted to the treatment of discharges and small articles; however, the inferiority of bichloride as well as carbolic acid in the treatment of discharges and articles about the sick room compared with boiling water is easily appreciated.

Bichloride of mercury is soluble in two parts of boiling water and fourteen parts of water at the temperature of the room. By dissolving one-half pound of the dry salt in a gallon of hot water and allowing the liquor to cool an almost saturated solution may be obtained.

*Carbolic Acid.*—Pure carbolic acid is colorless with a strong characteristic odor and below a temperature of 40° C. crystallizes into needles. If a trace of tar is present which usually occurs in the commercial product it turns to a reddish color on exposure. It is soluble in about twenty parts of water in ordinary temperature; therefore a five per cent. solution is the strongest that can be made. Carbolic acid does not actively coagulate albuminous matter, nor does it set stain in clothing like corrosive sublimate.

During recent years the laboratory has produced various disinfectants largely from coal tar, and their coefficient value as compared with carbolic acid has been given, and in various ways they are of practical value.

*Lime.*—This agent in the form of whitewash is a valuable application in and about stables or for walls and ceilings in filthy and unsanitary apartments; however, the reputation of lime depends rather on its very important and valuable action as a deodorant which is particularly apparent when used in combination with copper; one pound of unslaked lime and one pound of sulphate of copper added to ten gallons of water, commonly one application of this to decomposed organic matter will permanently neutralize the offensive odor.

Reference has been made in the above list only to disinfecting agents which are in general use although there are others which have received extended consideration; however, the intent of this article is to deal with infection and disinfection from a modern and practical sanitary standpoint and not to discuss in detail the various disinfectants which in recent years have rapidly multiplied.

There is little doubt in the minds of practical sanitarians that cleanliness, consisting largely of the free use of soap and water, is more important as a preventive measure than disinfection, although the latter is of positive value in the treatment of the discharges of those who have infectious diseases, and the various articles and material used about their person; however, we should bear in mind that it is the person and not the apartment or environments which constitute the source of infection. This statement does not rest upon theory but upon the result of careful and extended practical observation.

Not long ago it was generally believed that the large increase in the number of cases of measles, scarlet fever, and diphtheria, which occurred at the opening of the school year was due principally to the transmission of these diseases by the clothing of well children in whose home infectious diseases existed; this has been proven otherwise. In many instances municipal health authorities have organized what are termed school corps, consisting of medical inspectors whose duties consist in the examination of public school children. This work has presented conclusive proof that children having various infectious diseases in a mild or unrecognized form, or acting as "carriers," are frequently found in schools. Apparently simple sore-throats have proven to be the local manifestation of mild cases of scarlet fever, in many instances coryza has been found to be associated with measles, and bacteriological examinations of the discharge from the throat and nose of children apparently well have often shown the presence of diphtheria bacilli. These conditions are not occasionally but commonly met with and offer a reasonable and scientific explanation for the increase in the number of cases of infectious diseases at the beginning of the school term. To a certain extent this same condition occurs among employes. With adults it refers principally to the frequency with which tuberculosis occurs, therefore protection against infectious diseases depends largely upon the early detection of those who are affected particularly where large numbers are brought together. In some directions the undeserved reputation of disinfection as a preventive measure has masked the value and importance of careful observation to detect the presence of those who are infected and in this way has contributed to the extension of infection.

The disinfection of schoolhouses and public buildings, and the ever-recurring subject of car sanitation afford excellent illustrations of the misunderstanding regarding the danger from these sources. People do not

as a rule contract diseases from public school or other buildings or cars or other public conveyances, but rather from persons who are in them, notwithstanding many statements to the contrary. In addition to the frequency with which infectious diseases are transmitted by mild and unrecognized cases we have more recently obtained definite and extended knowledge of the frequency with which "carriers" exist, *i.e.* persons who while they may present no evidence of disease themselves, contain actively infectious organisms within their body which may be transmitted to others. These facts teach us that it is the detection of the source of infection rather than general disinfection that we must depend upon to prevent the transmission of infectious diseases. It is quite true that many forms of bacteria are found wherever there is exposure, and pathogenic organisms may be detected, still the danger of contracting disease through these sources except where actively infected articles or material may contaminate the hands, food or drink, is very remote and aside from careful attention being given to these possible media of infection we need not worry about the danger of the rooms or vehicles themselves, particularly if cleanliness and the free use of soap and water is employed.

Germs are found on money, still there is the most striking and conclusive evidence that this article does not transmit disease; this is also true of clothing, rags, and other articles and material in general use. If the home and workshop are kept constantly cleaned and ventilated disinfectants need not be used except in the presence of infectious diseases. In recent years disinfection has become largely a commercial matter and the benefits through this source are extolled by those who have germicidal agents to sell and who deal with the subject largely on theoretical grounds; this is not only misleading to the public but belittles the real protection against infection, *i.e.* the early detection of disease and the observance of personal hygiene and cleanliness.

Heretofore the belief that desquamation in measles and scarlet fever is an important factor in the transmission of these diseases has overshadowed the danger of the discharges from the head; but little attention has been paid to their destruction and mothers and attendants have handled them without fear and often without washing their hands. Now it is quite certain that these discharges constitute the principal if not the only source of infection in connection with these diseases, and modern treatment calls for the most scrupulous care in the destruction of the discharges and cleanliness of the patient and attendants, particularly the hands of the latter.

In hospitals for the care of measles, scarlet fever, and diphtheria which have come under my direction, cases were treated in apartments adjoining each other with only a dwarf partition between them and without the transfer of infection. The care of these cases aside from the medical treatment depended chiefly upon the constant removal and destruction of the discharges and general cleanliness, particularly of the hands of the nurses. In order to add still further protection the nurses while removing the discharges were required to wear rubber gloves which after removal were disinfected in boiling water and the hands of the nurse were carefully cleaned. As a result of this method, infection was not transmitted from one ward to another although in some instances it was necessary for the nurses to deal with more than one apartment and with different infectious diseases.

I cannot speak too strongly concerning the careful cleansing of the hands while in the presence of infection. It is true that an attempt is usually made to conform to this important requirement but it consists largely in dipping the hands in a solution of carbolic acid or bichloride of mercury. This has but little value unless the hands are immersed for a minute at least, but an exposure of this length is not usually made; besides the essential feature is first thoroughly cleaning the hands with soap and water. The destruction of the discharges which are usually removed from the patient by gauze or other textile fabrics is most effectively carried out by boiling. Reference has already been made to apparatus which may be improvised or specially constructed for this purpose for use in the sick room or hospital. By simple and inexpensive means infection may be quickly destroyed without injury to the material involved. There is no disinfectant which equals this in safety, economy, and rapidity of action. It is true that other disinfecting solutions may be used for the purpose and if sufficient exposure occurs a germicidal action will be obtained, still this means of disinfection cannot always be depended upon and besides their action is comparatively very slow. However, it must be carefully remembered that the common practice of immersing articles in boiling water and immediately allowing it to cool cannot be depended upon to disinfect, for to secure this result the water must be continuously boiled for at least fifteen minutes.

In place of boiling water a 1–1,000 solution of bichloride of mercury with an exposure of an hour, or a three per cent. solution of carbolic acid with an exposure of half an hour may be used.

Probably no discharges are more carelessly dealt with than the stools of typhoid fever cases. The method usually employed consists in placing a disinfectant in the bedpan before or after the discharge is received, the mixture being allowed to remain probably an hour or less before it is emptied. This method does not insure disinfection; besides, by handling or manipulating the receptacle, the nurse or attendant often becomes infected, for she has faith that this treatment answers all requirements. Some time ago I made a series of experiments in connection with this detail; they consisted in adding to fecal matter the various disinfecting solutions which are used for this purpose and in the manner in which they are employed. It was found at the end of twenty hours that but one-eighth of an inch of the mass was disinfected. These experiments were subsequently repeated by others with practically the same results, and I believe prove that this method of disinfecting stools is of little or no value; and it is not improbable after this treatment, when the fecal matter has been thrown into the water closet or privy vault and has become disintegrated, it may act as a medium of infection.

It is true that the discharges of cholera more quickly succumb to disinfecting agents, still these conditions are somewhat uncertain and we should take no risks when we have means at our command which will secure full protection.

One great safeguard in placing the receptacle containing the stool directly into the boiling water without emptying it lies in the fact that both are promptly disinfected and the danger of infection during the process of removing the contents of the pan and the alleged cleaning the latter is practically avoided.

ALVAH H. DOTY.

**Dislocations.**—A dislocation or luxation is an abnormal and permanent separation or displacement of the articular surfaces of the bones composing a joint.

A self-reduced dislocation is called a sprain (Graham), and a partial dislocation is called a subluxation.

As to the general causes, dislocations are said to be:

(1). *Traumatic*, the result of an injury.

(2). *Pathological* or *spontaneous*, the result of disease or destruction of tissues about the joint.

(3). *Congenital*, the result of a malformation that has occurred prior to birth.

Nearly all dislocations are *traumatic* and the displacements are aided by muscular action.

*Pathological* or *spontaneous dislocation* occurs in joints lax by disease, yet there is apt to be some slight force applied to the limb or part that assists greatly in the production of the dislocation. Destructive alteration of the joints takes place in a variety of diseases. Tabes dorsalis and syringomyelia are most prominent. Syphilis, tuberculous synovitis, typhoid fever, and rheumatoid arthritis may also cause destructive conditions of the joints. According to Rixford[1],

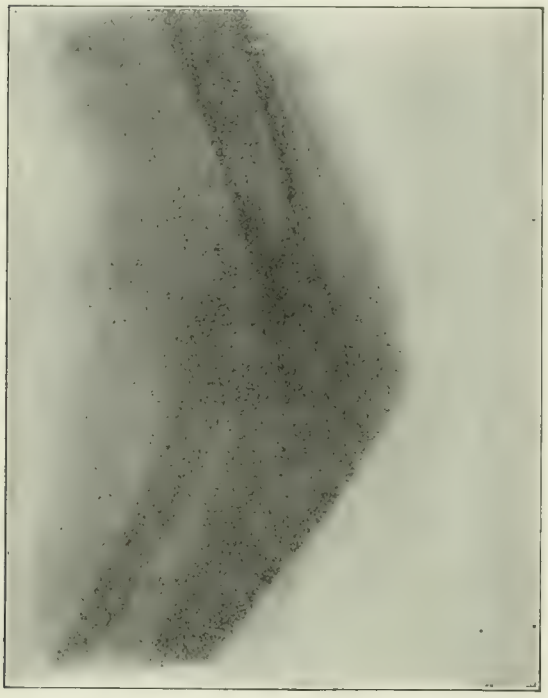

Fig. 1717.—Pathological Dislocation of the Head of the Radius forward in Tuberculosis of the Elbow. (Rixford, in the Am. Practice of Surgery.)

neuropathic arthritis affects the large joints by preference, most frequently the knee and hip in tabes, and the elbow and shoulder about as frequently in syringomyelia. Tuberculosis affects the ligaments as well as the articular ends of the bones and thus causes pathological dislocations. In hip disease, the tuberculous process may erode both the upper rim of the acetabulum and head of the femur, giving rise to a backward dislocation of the hip-joint.

Suppurative arthritis may cause necrosis of the bone or bones entering a joint and thus permit of a pathological dislocation.

*Congenital* dislocations take place most frequently in the hip- and shoulder-joints. Lorenz and Hoffa have devised bloodless methods for the reduction of congenital hip dislocations, but paring down the head to fit the glenoid cavity according to Phelps, or even excision of the head, is the plan usually resorted to for the shoulder.

Numerous theories are advanced in regard to the causation of congenital dislocations, some of which are: external violence affecting the uterus during pregnancy; muscular retraction, which in turn is due to change in the central nervous system; paralysis of muscles; maldevelopment preventing the formation of normal articular surfaces, etc.

Varieties.—A dislocation is said to be *complete*, when the articular surfaces are entirely separated from each other; *incomplete* or *partial*, when the joint surfaces at some point remain in contact; *simple*, when the separation of the bones is attended by only a limited or reasonable degree of injury to the soft parts, and no wound leads from the surface or skin to the joint; *compound*, when there is a wound leading from the surface to the joint, or when an articular surface of a bone is protruded externally through the soft parts; *complicated*, when additional injury or trauma results, such as a fracture of one or more of the bones entering a joint, laceration of important blood-vessels, nerves, muscles, etc., or an extensive or serious visceral or organic lesion; *single*, when only one joint is involved; *double*, when two corresponding joints, usually on opposite sides of the body, like two shoulders, are luxated; *multiple*, when two or more joints are involved; *unilateral*, when one side of an articulation of a bone, like the lower-jaw, is out of place; *bilateral*, when both sides of an articulation of the median bone is dislocated; *primitive* or *primary*, when the bone or bones remain in the original situation and do not by force or muscular action shift to some other situation; *secondary* or *consecutive*, when the dislocated bone or bones assumes a new position from the one originally occupied; *recent*, when the articular extremity of the bone is not fixed by adhesions—when the dislocation has taken place within a few days or weeks, a sufficient time not having elapsed to produce material changes, such as result from inflammatory exudate or other processes that are likely to impede reduction; *ancient* or *old*, when fastened by adhesions or new-formed tissue and when the socket is more or less obliterated; *habitual* or *relapsing*, when the dislocation constantly recurs from usually slight force, because the ligaments are relaxed and oftentimes extensively lacerated.

The term *Diastasis* is employed to indicate a direct separation of articular surfaces, without gliding upon each other, as when the pubic bones separate at the symphysis.

Special dislocations are sometimes designated by the name of the joint involved, as dislocations of the shoulder, hip, elbow, etc.; more properly, however, the proximal end or ends of the distal bone or bones involved give the designation; and yet, in the case of the clavicle, it is more usual to speak of a dislocation of the sternal or of the acromial extremity, and not of the clavicle alone in the one instance, and of the scapula in the other

Etiology and Mechanism.—In our discussion of the predisposing causes of dislocations, we must consider, first, the forms of the various joints. Thus, for example, the shallow glenoid cavity—if such it can be called, at the shoulder-joint—is quite different from the deep cup-shaped acetabulum, although both are known as ball-and-socket joints. Under normal conditions, the ligaments which enter into the formation of the shoulder-joint—viz., the capsular, the coracohumeral, and the glenoid—are conspicuously weaker than those which form a part of the hip-joint—viz., the capsular, iliofemoral, cotyloid, and transverse ligaments, and the ligamentum teres; and consequently luxation can much more readily occur in the former than in the latter. Ball-and-socket joints, from their greater range of mobility, are, as a rule, more liable to luxation than ginglymoid or hinge joints. In the next place we must consider how the different component parts of a joint are altered under abnormal conditions. Thus, for example, by overstretching of the ligaments in early life undue relaxation of the latter may be produced. Such overstretching may be brought about by the abuse of the natural functions of the joint, as well as by the normal growth of the bones themselves. Relaxation of the ligaments may be congenital or it may be the result of disease, which may

also produce softening of the capsule as well as of the bones. Excessive action of antagonizing muscles, and defective contractility, from paralysis or impaired nerve function, are not only to be classed as predisposing factors, but may be the direct causes. Age is unquestionably a predisposing factor, and sex has its influence. Habit, occupation, etc., also have bearings upon the question of predisposition.

Of the exciting causes, we consider of first importance violence or force. In most cases the dislocation results from a combination of forces, being partly the result of a blow and partly that of muscular action; yet either will suffice in some cases. Prof. Frank H. Hamilton[2] says: "The action of certain ligaments in determining the direction of some dislocations is also a direct cause, but only subsidiary to the other causes named.

"External violence operates either directly or indirectly. When a person falls upon the knee and dislocates the head of the femur, the force is said to have acted indirectly, and this is by far the most frequent mode of dislocation; but when the blow is received upon the upper end of the humerus, and the head is sent into the axilla, it is said to have been dislocated by direct violence.

"Muscular action produces dislocation slowly, as in severe cases of chronic rheumatism, and then it is termed a spontaneous or pathological dislocation; or suddenly, as in the violent spasmodic contractions which accompany convulsions; or sometimes by the mere voluntary effort of the muscles; and both of these latter are true accidental dislocations.

"It is very probable that external force can seldom be regarded as the sole cause of a dislocation, but that, in a large majority of cases, muscular action coexisting with shock performs an important rôle in the history of the accident. The limb, being driven obliquely across its socket by the external violence, is seized by the excited and stretched muscles with such vigor as to contribute not a little to the unfortunate result. Thus it will be found that the same force which is adequate to the production of a dislocation in the living subject is wholly insufficient to accomplish the same in the dead; and a man who is fully intoxicated seldom suffers from a dislocation."

Frequency of Dislocations.—The following tables are taken from Stimson's "Fractures and Dislocations," revised sixth edition, 1910, and are reproduced in full.

"Compared with other surgical injuries, dislocations are infrequent; the proportion to fractures about 1 to 10.

"These tables show the great relative frequency of dislocations of the upper extremity as compared with those of the lower. Each set of statistics shows that dislocation of the shoulder is far more common than that of any other joint, and that next in frequency come dislocations of the elbow. These two dislocations may be estimated as together comprising from two-thirds to three-fourths of all cases, excluding the phalanges.

"As between males and females, Malgaigne and Gurlt found the injury three times as frequent in the former as in the latter; Kroenlein found it five times as great. Dislocations of the lower jaw are an exception, being found four times (Kroenlein) as frequent in women as in men.

Dislocations at the Hudson Street Hospital, New York, 1894–1905.

| Hospital and Dispensary. (Lewis A. Stimson.) | | |
|---|---|---|
| Hip, dorsal | 19 | |
| Hip, thyroid | 3 | |
| Knee | 12 | |
| Semilunar cartilage | 13 | |
| Patella, outward | 9 | Lower extremity, 89–5.82 per cent. |
| Head of fibula | 1 | |
| Ankle | 5 | |
| Astragulus | 5 | |
| Subastragaloid | 5 | |
| Metatarsus and phalanges | 17 | |
| Clavicle, outer end | 69 | |
| Clavicle, sternal end | 12 | |
| Shoulder | 617 | |
| Elbow | 156 | |
| Head of radius* | 18 | |
| Ulna, upper end | 13 | |
| Ulna, lower end | 8 | |
| Carpus | 7 | Upper extremity, 1,368–89.59 per cent. |
| Trapezium | 1 | |
| Semilunar | 5 | |
| Scaphoid | 3 | |
| Os magnum | 1 | |
| Metacarpal | 80 | |
| Metacarpo-phalangeal and phalangeal | 378 | |
| Lower jaw | 61 | |
| Vertebræ | 6 | Head and trunk, 70–4.58 per cent. |
| Chondrosternal | 1 | |
| Sacroiliac synchondrosis | 2 | |
| | 1,527 | |

* Including cases with associated fracture.

Table of Four Hundred Recent Traumatic Dislocations. Hospital and Polyclinic. (Kroenlein, as given by Stimson in "Fractures and Dislocations," Sixth Edition, 1910.)

| Joints. | | Sex. | | Age. | | | | | | | | Totals. | | | Percentages of frequency. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M. | F. | 1–10 | 11–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 | | | | |
| Hip | Iliac | 4 | | 2 | | | 1 | | 1 | | | 4 | 8 | 2 | Lower extremity, 20=5 |
| | Obturator | 2 | 1 | 2 | | | | | | 1 | | 3 | | | |
| | Pubic | 1 | | | | | | | 1 | | | 1 | | | |
| Knee | Lateral | 4 | | | 1 | 1 | 1 | | 1 | | | 4 | 7 | 1.7 | |
| | Patella outward | 2 | 1 | | 2 | 1 | | | | | | 3 | | | |
| Foot | Backward | 1 | 1 | | | | 1 | | | 1 | | 2 | 0.5 | | |
| Metatarso-phalangeal | | 3 | | | 1 | | | | 1 | | | 3 | 0 7 | | |
| Shoulder | Subcoracoid and axillary | 180 | 23 | | 2 | 53 | 44 | 43 | 35 | 19 | 2 | 203 | 207 | 51 7 | Upper extremity, 369=92 |
| | Erecta | 3 | | | | 2 | 1 | | | | | 3 | | | |
| | Infraspinous | 1 | | | | | | | 1 | | | 1 | | | |
| Elbow | Of forearm backward | 77 | 17 | 22 | 44 | 14 | 5 | 4 | 3 | 1 | 1 | 94 | 109 | 27.2 | |
| | Of radius | 9 | 6 | 9 | 5 | 1 | | | | | | 15 | | | |
| Wrist | Dorsal of ulna | 1 | | | | 1 | | | | | | | 1 | 0.2 | |
| Metacarpo-phalangeal | | 23 | 4 | 4 | 6 | 8 | 4 | 8 | 1 | | | | 27 | 6.7 | |
| Interphalangeal | | 7 | 1 | 1 | | 5 | 1 | 1 | | | | | 8 | 0.2 | |
| Sternoclavicular | | 4 | 2 | 1 | 3 | 2 | | | | | | | 6 | 1.5 | |
| Acromio-clavicular | | 11 | | | 1 | | 1 | 4 | 3 | 1 | | | 11 | 2.7 | |
| Lower jaw | Unilateral | 2 | 2 | | 1 | 1 | | 2 | | | | 4 | 10 | 2.5 | Trunk, 11=2.8 |
| | Bilateral | | 6 | | 1 | 3 | 1 | | 1 | | | 6 | | 0.2 | |
| Cervical vertebræ | | 1 | | 1 | | | | | | | | | 1 | | |
| | | 336 | 64 | 44 | 69 | 88 | 65 | 60 | 48 | 23 | 3 | | 400 | | |
| | | 400 | | | | | | 400 | | | | | | | |

"The following table summarizes the other two with Malgaigne's statistics of Hotel-Dieu:

| | Cases. | Upper extremity. | Lower extremity. | Trunk. |
|---|---|---|---|---|
| Malgaigne, hospital | 491 | 85.7 | 12.6 | 1.6 |
| Kroenlein, hospital and polyclinic. | 400 | 92.2 | 5.0 | 2.8 |
| Stimson, hospital and dispensary. | 1,527 | 89.59 | 5.82 | 4.58 |

"*Age.*—No age is exempt; dislocations have occurred as early as the moment of birth and as late as the age of ninety years. The relative liability to the injury at different ages is shown, not by simply comparing the number of cases observed at those ages, but by also comparing the number of people at those ages living in the community where the observation is made. This comparison has been made by Kroenlein for Berlin, with the following results:

Frequency of Dislocations at Different Ages.

| | Age decades. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1–10 | 11–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 |
| Absolute frequency | 44 | 69 | 88 | 65 | 60 | 48 | 23 | 3 |
| Relative number of people living | 1,872 | 1,620 | 2,529 | 1,679 | 940 | 599 | 282 | 117 |
| Relative frequency as computed for equal number of people | 10 | 18 | 15 | 16 | 27 | 35 | 35 | 10+ |

"From this it appears that a smaller proportion of individuals between the ages of 1 to 10 and 71 to 80 years receive dislocations than in any other decade of life; and the highest proportions are found between the ages of 51 to 60 and 61 to 70. It is further to be noticed that dislocation of the shoulder is very rare, and that of the elbow very common, before the age of 21 years. Kroenlein's table shows that of 207 cases of the shoulder, in only 2 were the patients less than 21 years old, and that 109 cases of the elbow 80 were no older, the age in 31 being between 1 and 10 years, and in 49 between 11 and 20 years. Compared with fractures, it appears that the liability to dislocation is least during those periods of life in which the liability to fracture is greatest; that is, in infancy and youth and in old age; the latter part of this statement may need some modification, for while dislocations are rare after the age of 70, they are relatively frequent in the preceding decade. The liability to each increases from adolescence through middle life."

General Symptoms and Diagnosis.—The most prominent symptoms are pain and deformity; loss of normal function, as shown by impaired mobility, though in some instances we may have increased mobility; change in the length and direction of the limb; change in the natural axis of the limb with its socket; the fact that when the dislocation is reduced, the parts if undisturbed, remain as a rule in position. In some of the joints the peculiar appearance of the one injured suffices to indicate the lesion, yet the swelling from injury to the tissues, which soon arises, may alter not only these appearances but also the conditions ascertained by palpation. Immobility or other impairment of function and pain on motion may be marked features of certain fractures, yet when the patient is under the influence of anesthesia, we shall often be able to discover certain peculiar differences between these cases. These differences will be noted when we come to consider the special dislocations. While there is usually lengthening of the limb, especially in downward dislocations of the shoulder and hip, yet in other instances to be mentioned there may be marked shortening; as to the changes in direction, as well as to the retention of the parts in position after they have once been reduced, these matters require only to be mentioned at the present moment. In dislocations of some days' or weeks' standing, inflammatory exudations may so roughen opposed surfaces as to produce a sensation not unlike that of crepitus; yet it ought to be possible under careful examination, and especially if the patient is put under the influence of an anesthetic, to distinguish this sensation from the sharp, grating sound which is pathognomonic of a fracture. We must remember, however, that some fractures are not accompanied by crepitus, and these are mostly found in the vicinity of a joint; that epiphyseal fractures are attended by a more muffled or indistinct crepitus than others; and that occasionally the dislocation may be accompanied by a fracture of the head of the bone or in its immediate vicinity. It is under conditions like these that the revelations of the Roentgen ray are of especial value. I desire to state, however, that in my experience—although in some dislocations, especially those which have existed for some length of time, I have derived great satisfaction from the use of the *x*-ray—it has signally disappointed me in those occurring at the hip. In the case of the more superficial joints, such as the elbow and wrist, or even in those in which there is a smaller amount of bony structure (the shoulder, for example), it has been of the greatest service. While in some cases we may have one or more symptoms that are really pathognomonic, we often encounter cases in which it is a very difficult matter to make a correct diagnosis. However, if the surgeon possesses a thorough knowledge of the structures which enter into the formation of the various joints, if he knows what was the condition of the limb prior to the injury, and if he makes a careful collation of the facts relating to the manner in which the injury was produced, he should be able, in recent cases, to decide upon the measures that are best adapted to afford the needed relief.

General Pathological Considerations.—The first results of an accidental or traumatic dislocation are the rupture and tearing of the capsular and other ligamentous structures; contusion or laceration of muscles, tendons, and other adjacent tissues; and injury to blood-vessels and nerves. If an early reduction is effected, and if the joint is allowed to rest for from ten to twenty days, or even longer in some cases, the recuperative powers of nature will usually prove sufficient for the repair or restoration of all these pathological lesions. Under certain circumstances, however, a wounded blood-vessel may demand immediate ligation, or a torn nerve or ligament require suturing, either at once or at some later period. The laceration of ligaments and other soft parts, together with the rupture of even unimportant blood-vessels, will cause more or less immediate effusion of blood, and subsequently of serum. This alone, independently of the pressure of the misplaced bone and overstretched ligaments and tendons that are not torn, will, through pressure on sensitive nerves, occasion pain,

of varying severity. Then, besides, the contractility of certain muscles may become impaired, either immediately after the accident or at some later date, through the injury inflicted upon the motor nerves in the vicinity of the luxation. As time goes on, if the dislocation is not reduced, other changes of a far more serious character will occur. The inflammatory exudation may become organized, and in this way the laceration in the torn capsule may possibly be closed. At the same time natural bony cavities, such as that of a ball-and-socket joint, are likely to become filled, to a greater or lesser extent, with exudative material. Torn ligaments and tissues become reunited in abnormal positions. Some muscles kept in too high a state of tension, and others from want of use, undergo atrophy and become impaired in their contractility. Some blood-vessels and nerves are unduly stretched, while others become contracted in their length—a matter of serious moment in the aged. Gradually changes in the bones occur, and the dislocation passes from the condition of a recent lesion to that of one which occurred a long time previously—in brief, to that of a permanent or irreducible dislocation. As to these later changes, I cannot do better than to give here the following quotation from Professor Hamilton, which I regard as graphic and instructive:

"If the dislocation remains unreduced, the margins of the old socket, in the case of enarthrodial articulations, become gradually depressed, while the concavity of the socket is filling in with a fibrous or bony tissue, until at length the whole of this portion of the joint apparatus is nearly or entirely obliterated. This process is generally very slow, and may not be consummated until after the lapse of many years.

"At the same time, but with much greater rapidity, the head of the bone in its new position, and the soft or hard parts on which it rests, are undergoing certain changes to adapt them to their new relations, and calculated in some measure to restore the limb to its normal functions. If the head of the bone rests upon muscle, the cellular and fibrous tissues which enter into the composition of the muscle become condensed and thickened, forming a shallow or elongated cup, whose margins are attached to the neck or shaft of the bone, and whose walls are lubricated with synovia. If it rests upon bone, by a process of interstitial absorption a true socket is formed, sometimes deep, and sometimes shallow, whose edges, receiving additional ossific depositions, become lifted so as to form a rim. At the same time the head of the bone is undergoing corresponding changes, to adapt itself to the newly formed socket; it is flattened or otherwise changed in form, and in the progress of this change its natural secreting and cartilaginous surfaces are gradually removed, a porcelaineous deposit taking its place. The same kind of hard, polished, ivory-like deposit is found also in those portions of the new socket which have been especially exposed to pressure and friction. Instead of the eburnation, an imperfect fibroserous surface or synovial capsule may be formed."

"I have in my cabinet," he says, "an example of ancient luxation of the hip-joint in which the head of the femur, having rested upon the dorsum ilii, has formed a nearly flat but smooth surface—a kind of elevated plateau; in other cases I have seen the margins of the new socket so elevated as to rest against the neck of the femur, and completely lock it in.

"Coincident with these changes, and in consequence partly of the disuse of the limb, the muscles and even the bones sometimes suffer a gradual atrophy. In some measure these alterations may be due also to the pressure of the dislocated bone upon arterial and nervous trunks, by which their functions become partially or completely annihilated, and their structure may be wholly obliterated. In consequence also of the inflammation which immediately results, we ought not to omit to notice that the trunk of a large artery sometimes becomes firmly adherent to the capsule or periosteum of a displaced bone, and its reduction is attended with imminent danger of laceration and of a fatal hemorrhage. Numerous instances of this grave accident, especially in attempts to reduce old dislocations of the shoulder-joint, are upon record."

This quotation from a master in this special line of work is so in consonance with my own views and observations, and has such an important bearing on the prognosis and treatment of luxations, that I feel no hesitation in reproducing it in this place.

In those cases in which a dislocation of a ginglymoid or hinge joint is not early reduced, the bones may accommodate themselves more or less satisfactorily to the changed relations, and motion more or less practical may be regained, but the comparative restoration of function is never, or at least very rarely, so satisfactory as that of the ball-and-socket joint.

The degree of disturbance is not so marked in spontaneous or pathological dislocations as it is in those of the traumatic variety; the capsule and other ligaments may be stretched only, and not torn; the lesions of other structures are not necessarily present; and if the material changes above mentioned do result, they are later in developing. In compound dislocations, all those additional lesions which may characterize a compound fracture—the result of suppuration or other action caused by contamination from without—are, as a rule, intensified. If complications exist, their nature, and the possibility that they may produce features of greater importance than the dislocation itself, or perhaps even a fatal termination, must be carefully and thoroughly considered.

General Prognosis.—In dislocations so much depends on the character of the particular joint involved that this subject will to a great extent be left for subsequent consideration. I may state, however, that in recent dislocations restoration of function, more or less complete, may be confidently expected when the reduction has been successfully effected, and when the proper after-treatment has been carried out; yet it is proper to state that very few joints, after they have once been completely displaced, are ever perfectly restored. They are not only more prone to undergo subsequent dislocation when subjected to a smaller degree of force, but they are apt, for a period of many years or even during the life of the individual, to manifest other sequelæ of the original accident—such, for example, as a partial defect of mobility, diminished size and power of the muscles, and more or less pain. This latter symptom may be persistent in character or it may recur from time to time, these characteristics depending to some extent on the joint injured, on the nature of the injury, on the length of time which has elapsed between the receipt of the injury and the reduction of the dislocation, on the means employed in effecting the latter, on the subsequent condition of the patient, and on various other conditions peculiar to the joint involved. As a rule, we can never promise as satisfactory a result as we can in a case of fracture of like character.

The possibility of malpractice suits must not be lost sight of. We have the usual history of a dislocation with swelling either before or after reduction. The patient is possibly informed that an early recovery may be looked for, with perfect usefulness of the limb. After the pain and swelling subside, there is much surprise, on the part of the patient, at his increasing inability to use the limb—*e.g.* the hand and forearm in shoulder luxations, and the foot and leg in those of the hip—and soon well-marked symptoms of muscular atrophy may develop. Accompanying the injury there has perhaps been a contusion of one or more nerves or plexuses, and in consequence of this a peripheral neuritis develops, the symptoms of which are obscured by those necessarily attending the dislocation itself. The prognosis which was

given by the surgeon is not fulfilled, and the early recovery promised does not take place. As a result, the patient, naturally disappointed after months of invalidism and possibly more or less suffering, eventually becomes convinced by some means or other that he is permanently disabled. The idea takes possession of him that a surgeon who has been so incorrect in his prognosis must have been deficient in the matter of treatment, and a suit for malpractice is regularly instituted.

The possibility of nerve injury should never be lost sight of in any important dislocation. In some cases it may be accompanied by a paralysis which manifests itself immediately after the inception of the injury. In other cases the paralysis does not develop until later. At first there may be only a slight numbness or tingling, the paralysis due to the neuritis coming on several days, or one or two weeks, or even a longer period, after the bone has been replaced. Before giving a definite prognosis the nerve supply should be carefully studied—if necessary, for a period of several days, or even for a week or more. During this time both sensation and motion should be carefully tested, and some form of electric stimulus should be employed if the least doubt or uncertainty remains.

Drs. Keen and White[3] say that: "In uncomplicated cases reduction is habitually followed by repair of the torn capsule and ligaments, but complete restitution to the normal condition may be prevented by faulty repair of some of the lesions, by periarticular thickening, by subperiosteal formation of bone in the young, or by more or less thickening of the joint. Thus, at the shoulder, the ruptured tendon of the supraspinatus and the upper part of the capsule may fail to reunite, and the patient be thereby exposed to frequent recurrence of the dislocation. . . . . At the elbow, the stripping up of the periosteum from the posterior aspect of the external condyle may lead to such thickening of the bone as will limit extension." These, with other features of special prognostic importance, will receive due attention further along in this article.

General Treatment.—It is now the accepted rule that recent dislocations should be reduced, or the parts restored to their normal position, at the earliest possible moment. Ease of reduction and diminution of pathological factors demand this. However, contingencies may arise that may justify a delay for a few hours or days. Shock, if not too profound, may aid in the immediate reduction by causing relaxation of opposing tissues and freedom from pain; yet extreme shock demands consideration just as much as do the associated injuries.

At the present day, manipulations made by the surgeon, either alone or aided by assistants, usually suffice for the reduction of a recent dislocation. These manipulations consist in a succession of gentle but firm movements communicated to the limb, by means of which the head of the bone is enabled, with the aid of the untorn ligaments, to re-enter the torn capsule and be rolled or slipped back into its position. In the carrying out of this procedure the tension of opposing muscles is relaxed and the contraction of others is increased. Manipulation is regarded by some as only applicable to typical or regular dislocations, but by the exercise of care irregular luxations can first be converted into regular, and then they may be reduced with ease. Kocher's method of reducing anterior dislocations of the shoulder, and that employed by Prof. Nathan Smith in dorsal dislocations of the hip—both of them now regarded as classical—are typical illustrations of manipulative methods.

Occasionally, spontaneous or pathological dislocations are restored by the unaided movements of the patient, and even accidental or traumatic dislocations have been reduced by another accident. In quite a number of American medical journals of recognized trustworthiness a case has been reported in which a man received a dislocation of the shoulder. He was placed in an ambulance, for removal to a hospital, by an interne who recognized the true character of the injury. On the way the horse became frightened and ran away, turning the vehicle over. When the patient was examined after this last accident it was found that the dislocation had been reduced by the fall.

I have already stated, in an earlier part of this article, that it is important for the surgeon to possess a complete and thorough knowledge of the structures entering into the formation of a joint. I deem this matter, however, to be of such importance that I now repeat the statement. Any one may, in certain instances, have the good fortune to succeed in reducing a dislocation, but if the medical man, after the employment of firm but gentle movements, with a strict avoidance of force or of anything like violent tugging at or twisting of the limb, fails to reduce the dislocation, it is far better that he should desist from further attempts until skilled technical aid can be obtained; and the same advice may be given with equal propriety to the physician or surgeon who does not possess a satisfactory knowledge of the joint involved. It is far better, both for him and for the patient, that other than the simplest efforts be deferred until such skilled assistance can be secured.

As regards the preliminary steps needed for the reduction of a dislocated joint, they may be stated as follows: The joint and the limb should be properly exposed and the patient should be placed on a good, firm table, with one or two cotton quilts, or comforters, or blankets under him; these being preferable even to a mattress, unless it should be a thin and somewhat firm one. Even the floor or the ground prepared as above is preferable to the yielding surface and other inconveniences of an ordinary bed.

If the injury involves one of the larger joints, or if the patient's muscular development is far in excess of that of the surgeon, or if he is extremely nervous and is suffering from acute pain—the first slight shock which to some extent not only temporarily paralyzes the muscular structures but also obtunds the pain, having passed off—the use of an anesthetic will be found of great service in establishing a correct diagnosis as well as in effecting the reduction of the dislocation. Because of the greater safety of ether, I rely upon it, as a rule, rather than upon chloroform; yet if the patient is either very young or of advanced age, or if there is any history of pulmonary or renal disease—which should always, if possible, be ascertained before the use of any anesthetic—I prefer the latter more powerful agent. In a simple case, in which the diagnosis is free from all doubt, if nervousness and acute pain are the only factors to be overcome, the primary anesthesia with ether, as first suggested by Dr. Addinell Hewson, may be all that is necessary; but if it be found that the local conditions are not so favorable as they often are, or if the patient is extremely nervous, feeble or diseased, and especially if he be suffering greatly from shock, the anesthesia should be pushed beyond the primary stage in order that complete relaxation may be secured before efforts at reduction are made.

If the reduction is essayed without an anesthetic, it is a good plan to keep up conversation on irrelevant topics during the examination and preparatory movements for reduction, thus diverting the patient's thoughts from the injury and from the preparations that are being made to relieve it. A short, sharp interrogatory or exclamation, made at the moment of greatest effort, has in many instances been of material aid in preventing or diminishing the contraction of antagonizing muscles.

While a certain degree of force is required in many instances, and the movements must sometimes be

made in quick or sudden manner, we should bear in mind that violence is never to be resorted to in recent dislocations. Relatively, the force exerted should not be more than the weight of the limb if separated from the body. The untorn part of the capsule and the other ligaments being already under a marked degree of tension, and certain muscles being in a state of contraction, our aim should be to slip the head of the bone over bony prominences and back through the rent in the capsule in much the same manner as we would slip a button into a button hole. Beyond this our efforts should not go; and while they may be exerted with firmness and at times with rapidity, they should be gentle and not violent.

In cases in which reduction is prevented by the interposition of a part of the capsule, or by the presence of other tissues, such as a muscle or a tendon, an open arthrotomy may be required; and this step may be necessary in the case even of the larger joints. When proper aseptic precautions are taken, the operation is reasonably safe, provided it is undertaken on or before the second day after the injury; but after this date we should wait until the third or the fourth week—*i.e.* until after reaction and inflammatory fever have subsided, and until the extravasated blood and serum have to some extent been reabsorbed—before we attempt so serious a procedure.

In the event of failure by manipulation, it will be found necessary to resort to extension and counter-extension or leverage to be made by our hands and by those of assistants; and, in a few cases, mechanical appliances will be required. In the first instance the surgeon, taking hold of the limb firmly with his hands, makes the extension, while the counterextension is maintained by his assistants; or, in some cases, both are made by assistants, and the surgeon simply manipulates the parts with his hands or fingers, or makes direct pressure on the bone in a proper direction. Finally, by employing his knee or his foot, as well as his hands, the surgeon can carry out both extension and counterextension without the aid of an assistant. In order to make extension various contrivances may be required. Such are: a folded bandage or handkerchief forming a clove hitch (Figs. 1718 and 1719) around the limb; the toy made of braided ash splittings known as the Indian puzzle; Levis' splint; Luer's or Charrière's forceps for the finger, etc. In order to apply the extending force effectively, broad strips of strong adhesive plaster should be attached along the anterior, posterior, and lateral surfaces of the previously shaved limb. They should be carefully adjusted and then they should be covered with a roller bandage, drawn moderately tight and forming loops which, in the case of shoulder, elbow, and hip dislocations, should extend beyond the extremity. Counterextension should be made by means of a folded sheet or towel placed in the axilla or perineum and firmly fixed or held there; or the shoulders or the pelvis may be kept immovable by means of properly padded straps that are fastened to the table or floor.

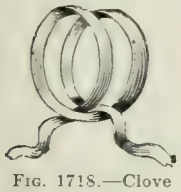

Fig. 1718.—Clove Hitch.*

In ancient or old dislocations it is best to make an open operation and raise the bands of adhesion rather than employ force and perhaps cause some complication as the rupture of an artery or vein or the fracture of a bone.

When it is necessary to resort to mechanical force or even to manipulations, in dislocations either recent or old, the surgeon must not lose sight of the fact of the possibility of injuring the patient by fracturing the bone or by lacerating or bruising the soft parts, especially the arteries and nerves. As a rule, the amount of force is to be determined by the surgeon in accordance with both the local and the general conditions observed in each individual case; good common sense and correct judgment must be his guide. While the serious accidents mentioned above have happened in the hands of some of the ablest surgeons, they are to be avoided rather than excused.

In simple dislocations the after-treatment consists in keeping the joint at rest for a variable length of time according to the joint involved, from ten days to two or three weeks usually sufficing; at the end of which time passive movements are carefully to be resorted to for several days, and then the patient may be permitted gradually and cautiously to resume the use of the joint. In some joints, as the clavicular, special dressings are essential, but ordinarily a sling for the arm, or a carefully adjusted bandage or other temporary support for a few days, is all that will be required. Compound and complicated dislocations require not only a longer time for recovery, but, in addition, the special treatment indicated by correct surgical technique for the particular condition that may be present.

Fig. 1719.—Clove Hitch as Applied to the Humerus, with Bandage Underneath.

Special Dislocations.—Dislocations of the Spine.—As these occur so rarely unaccompanied by fracture of some portion of a vertebra that enters into the formation of the joint, their consideration will be found in the article entitled *Spine, Surgery of the.*

Dislocations of the Lower Maxilla are comparatively rare. They constitute about four per cent. of all dislocations, being most common in females and most rare in childhood. They may be complete or partial, unilateral or bilateral, the former being by far the most frequent. Congenital dislocations are almost unknown. A predisposition may be furnished by a shallow glenoid cavity, the eminences being unusually low, or by relaxation of the ligaments, the result of disease or fatigue. Independently of any such predisposition, the direct *causes* are violence by blows or falls upon the chin, the mouth being open; over-wide opening of the mouth in gaping or hallooing; biting upon hard substances, etc. In the overfatigue and relaxation of the muscles of the jaw incident to prolonged dental operations, a sudden movement on the part of the operator or patient, or even the spasmodic contraction of the muscles of the jaw, has occasionally produced this form of dislocation. When the jaw is greatly depressed, the condyles move forward, carrying with them the interarticular cartilages; then they break through the capsular ligament and, gliding over the eminences, are drawn away from their articular surfaces by the action of the external pterygoid, the temporal, and the masseter muscles.

*Symptoms.*—In bilateral dislocation the mouth will be found open and fixed, the lower teeth projecting beyond the upper, the chin prominent, and the patient in great pain. The glenoid cavity is empty, and the locality is marked by a depression; the coronoid proc-

* This and several other illustrations which appear in the present article were prepared from drawings furnished by the late Dr. Edward M. Moore, of Rochester, N. Y., for publication with the text which he wrote on the same subject in the first edition of this Handbook.

ess and the tendon of the temporal muscle causing a prominence just behind the malar bone. In unilateral dislocation, the jaw is drawn to the sound side, giving the lower part of the face a twisted appearance; the jaws are somewhat separated and fixed; the mouth is partially open; and a depression is found in front of the ear on the injured side, with a prominence at

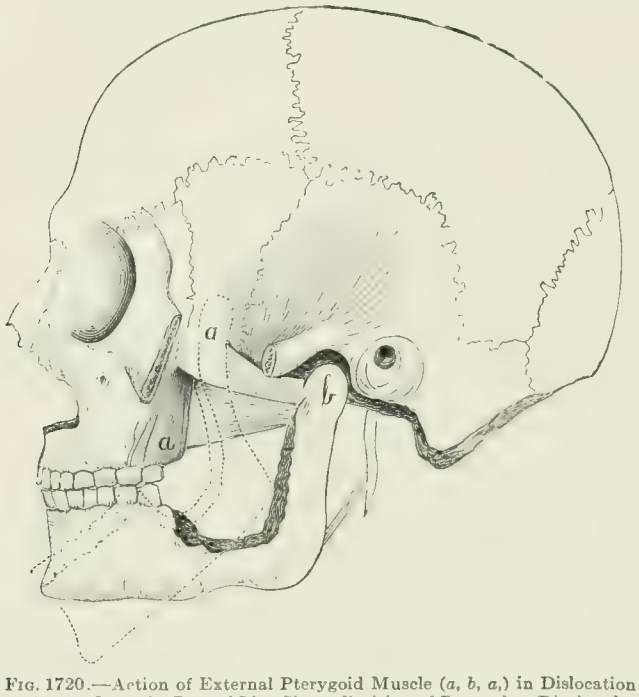


Fig. 1720.—Action of External Pterygoid Muscle (*a*, *b*, *a*,) in Dislocation of Lower Jaw; the Dotted Line Shows Position of Bone when Displaced.

the corresponding point on the opposite side. The lower molars project beyond the upper ones on the sound side, while on the other side the upper ones are external to the lower; the incisor teeth of the lower jaw project beyond those of the upper jaw and are carried toward the sound side. Dislocation is differentiated from fracture by the absence of crepitus, by the immobility of the jaw in the former condition, and by the prominence which a fragment of bone would cause below the zygomatic line in the latter. Furthermore, the chin is drawn toward the injured side in unilateral fracture.

*Treatment.*—If the dislocation is of recent occurrence, the patient should be seated in a chair while the surgeon stands in front of him. Having protected his thumbs by several thicknesses of bandage, by stout leather thumb stalls, or by leather gloves, to prevent injury to them by the involuntary closure of the jaws while reduction is being accomplished, the surgeon should pass them well back over the molar teeth of both sides, the jaw being firmly grasped by the fingers under the chin as it rests in the palms of the hands. Using the thumbs as a fulcrum, he should press firmly first downward and then slightly backward on the molars, the chin at the same time being elevated as a lever. In this manner, and with the aid afforded by the temporal and masseter muscles, he will probably be able to restore the condyle or condyles to their natural position. When these slip into position, usually with an audible sound, the surgeon removes his thumbs laterally to prevent their being bitten. Dislocations of some weeks' standing have been reduced by manipulation and without an anesthetic. If the patient is compelled to occupy a recumbent position, the surgeon will find his most suitable position to be on his knees, astride the patient's chest, or on his knees at the patient's head, the position of his hands being reversed. The head should, in all cases, be firmly fixed by a strong assistant. The discomforts and inconveniences of a dislocation of the jaw are so great that they are rarely permitted to become ancient; but in such event, or if reduction is found difficult or apparently impossible by reason of muscular rigidity and contractions, or on account of the patient's timidity or for other valid reasons, I do not hesitate to use an anesthetic, the patient being placed in the recumbent position and proper precautions being taken. In some instances wooden levers, or a strong-bladed knife, or a thin chisel may be needed to depress the condyles while the chin is being elevated.

In partial dislocations or subluxations, which are sometimes habitual and which are indicated by sudden immobility of the jaw, by a slight separation of the incisors, and by inability to approximate the teeth, the accident usually comes on while the patient is chewing or biting some hard substance. In this form of dislocation the articular surfaces do not leave the glenoid cavity; the interarticular cartilages merely slip behind the condyles and become fixed on the articular eminences. Under such conditions, therefore, it is usually an easy matter to effect a reduction by pressing with the fingers downward and backward on the coronoid processes, or by introducing a narrow wooden wedge or the blade of a dull table knife between the teeth and prying them open.

The after-treatment consists in applying a roller bandage, Barton's, a four-tailed bandage, or a mentocervico-occipital cravat or bandage to prevent or somewhat restrict the movements of the lower jaw for about ten days or two weeks, by which time the rent in the capsule will be closed. At the same time it is well to restrict the patient to fluid or semi-fluid diet, and he should be cautioned as to the movements of the jaw during this time and for some weeks after the dressing has been removed. Recurrence is by no means uncommon in luxation of the jaw. In one case, that of an hysterical female, I was required to reduce a bilateral dislocation seven times in thirty-three days.

Occasionally from too great laxity of the ligaments of the lower jaw, during ordinary movements, the

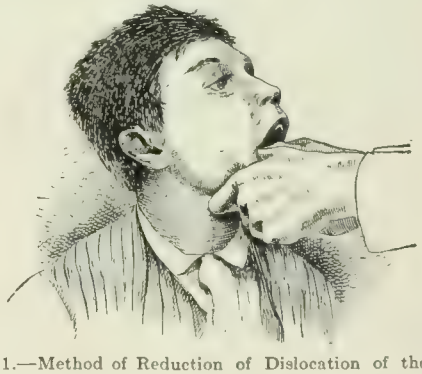

Fig. 1721.—Method of Reduction of Dislocation of the Lower Jaw. (Helferich.)

condyles slip forward on the articular eminences when the mouth is opened, and then as suddenly slip back, producing a slight noise as the mouth is closed. Drs. Wharton and Curtis mention the injection of a few drops of absolute alcohol into the ligaments as having been practised with success in such cases.

Dislocations of the Hyoid Bone are so rare that nearly all surgical works ignore them. Hamilton, in his very complete work, limits himself to quoting the two cases from Holmes' "Surgery" and the summary of the papers of Dr. Ripley of South Carolina and of Dr. Gibbs of London. Stimson's monograph on dislocations does not mention this bone, and Dr. Moore's article, in a former edition of this Handbook, gives the report of a single case which came under his observation. It also quotes the cases that are referred to in Holmes' "Surgery." In the case of the young man who was seen by Dr. Moore, it appears that he had always been able to restore the position of the bone except on one occasion. Ordinarily, he accomplished the reduction by bending the head forward and in the opposite direction from that in which the dislocation had occurred, and then rubbing the part. On the exceptional occasion referred to, it was found necessary to employ the suspensions apparatus ordinarily used for applying a plaster-of-Paris jacket. When the suspension had been pushed so far that the patient was obliged to rest upon the tips of his toes, the bone suddenly snapped back into place.

Dislocations of the Ribs and Costal Cartilages.—These injuries are seldom uncomplicated and are difficult to differentiate from fractures when displaced from the vertebræ. A diagnosis is rarely made and when occurring is treated like a fracture. The ribs are more often dislocated from their cartilages and form an anterior projection; there is depression at the cartilage and crepitus is absent as a rule.

*Treatment.*—Same as for fractured ribs. Reduce by placing the patient on his back upon a table with a sheet rolled up between the scapulæ, push back the shoulders and force the cartilage into place. Strap with adhesive plaster the same as in fractures.

Dislocations of the Sternum, although considered as such by many authors, scarcely deserve the name. While the union between the ensiform process and the middle portion or mesosternum does not take place until old age, and that between the mesosternum and presternum or manubrium not until after the fortieth year, the points of junction present scarcely any of the characteristics of a joint at any time, the movements being limited to the resiliency of the cartilaginous junction. However, we do in rare instances have displacements of the upper and lower portions from the middle. As a rule, these are caused by direct violence, and the injury partakes more of the nature of a fracture (resembling an epiphyseal fracture) than of a true luxation.

The displacement of the manubrium may be either forward or backward, the costal cartilages retaining their attachments; and with the displacement may be associated a fracture of the upper ribs or their cartilages.

The *Symptoms* are: projection of the lower portion of the manubrium upon the anterior surface of the chest in a forward displacement, and of the upper portion of the mesosternum if the manubrium is displaced backward; either of which alterations will be quite apparent from the limited amount of the tissues which cover the sternum at these points. Usually, the respiration is somewhat embarrassed, and there is pain, especially with the respiratory movements.

*Treatment.*—After the patient has been anesthetized—if there are no contraindications to the use of an anesthetic—the trunk should be flexed or extended and at the same time direct pressure should be made over the projecting portion of the sternum. In some cases a successful reduction may be obtained by these measures. No violent attempts, however, should be made, as the pain will in a few days disappear under rest, and recovery may be expected, although some deformity will remain.

The ensiform portion is occasionally displaced backward by a direct and sudden force applied over the epigastrium. Ocular inspection with palpation suffices to indicate the displacement, which may be accompanied by pain in the stomach, and occasionally by vomiting and labored or painful respiration. If reduction cannot be accomplished by passing the fingers below the ensiform cartilage and pushing it forward, an incision may be made under rigid asepsis, and the process drawn into position with one or two tenacula. The suggestion of Drs. Wharton and Curtis,[4] to excise the process, if the failure to effect a reduction should be followed by troublesome symptoms, is worthy of consideration.

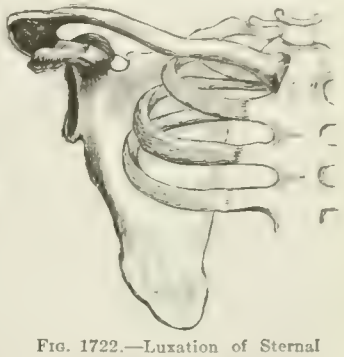

Fig. 1722.—Luxation of Sternal Extremity of the Clavicle.

Dislocations of the clavicle may occur at either end, the sternal or the acromial. If the usual custom as to dislocations in general were followed, a dislocation of the acromial end of the clavicle would more properly be designated as a dislocation of the scapula, but the term now used is so well established as to make it difficult to change it. These dislocations are usually single, yet Hamilton[2] cites a very interesting case of a double dislocation; and while it may

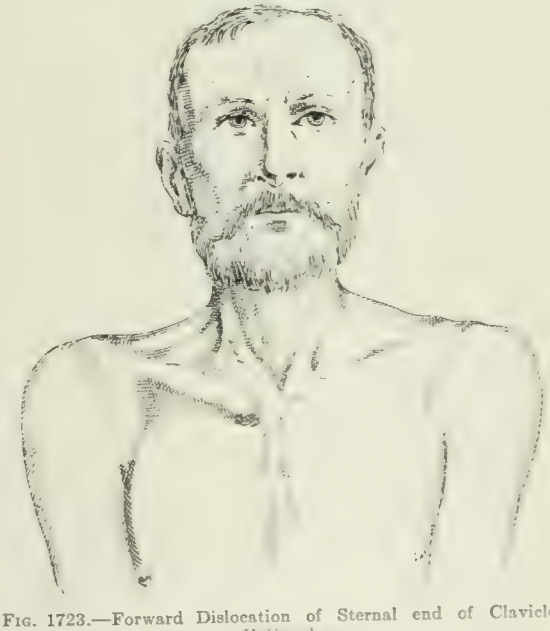

Fig. 1723.—Forward Dislocation of Sternal end of Clavicle. Helferich.

be "entire"—both ends of one bone being displaced at the same time—this is so very rare as not to necessitate consideration here.

"Of 57 dislocations of the clavicle," says Hamilton, "observed and recorded by me, 13 belonged to the sternal end and 44 to the acromial. Of those belonging to the sternal end, 11 were dislocations forward, forward and upward, or forward and downward, and 2 were upward. I have never met with a dislocation backward. Of the acromial dislocations

the whole number were dislocations upward, or upward and outward."

*Cause.*—The sternal end is usually thrown forward by a fall on the outer surface of the shoulder, in which event, as the force comes upon the anterior and outer surface of the shoulder, the clavicle is driven inward toward the median line and glides up on to the face of the manubrium, while the leverage exerted backward upon the acromial end tears loose the attachments of the opposite extremity. A direct force sufficient to drive the sternal end backward is more likely to result in fracture at or near the point of impact.

In dislocation of the sternal end forward, even in fleshy individuals, the head of the bone can be distinctly felt and seen lying on the front of the sternum, the shoulder on that side falling slightly back, and the head inclining slightly to that side, through traction on the muscles attached to the clavicle. The attachment of the sternocleidomastoid muscle to the clavicle is sharply defined, and by measurement the acromion can be shown to be nearer to the median line of the sternum. At the same time the movements of the arm are embarrassed, and there is acute pain at the site of the luxation. If the shoulder is elevated the head of the bone overlying the sternum will descend; if, on the other hand, it is depressed, the head of the bone will rise, and by drawing the shoulder back, the deformity may be made to disappear or at least to become less noticeable. A projection of the head of the bone or the presence of some other hyperplasia may mislead, and we must be on our guard not to overlook a fracture near the sternal end of the bone.

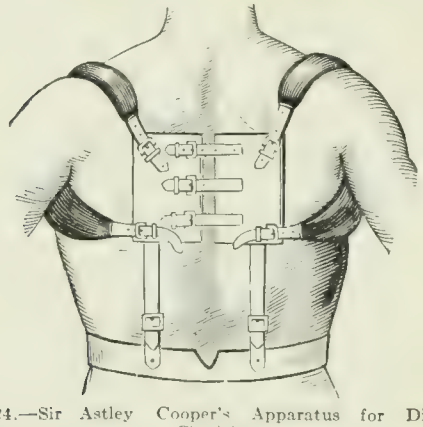

Fig. 1724.—Sir Astley Cooper's Apparatus for Dislocated Clavicle.

This variety of dislocation of the clavicle, though easy of reduction, is difficult if not impossible to maintain in the position of reduction. Hamilton says that in not a single one of the eleven forward dislocations seen by him was the treatment successful. Stimson is equally unfavorable as to complete correction of the deformity; and Wharton and Curtis say: "The prognosis is unfavorable as regards complete correction of the deformity, but favorable in respect to the restoration of function."

*Treatment.*—Reduction is effected by drawing the shoulder outward and slightly backward, pressure being made at the same time directly backward on the head of the bone as it is brought opposite the joint. For maintaining it in this position for the five or six weeks required for complete repair of the injured tissues, a variety of expedients have been suggested. A figure-of-8 bandage with a firm compress over the head of the bone; Récamier's dressing for fractured clavicle: Sir Astley Cooper's apparatus aided by direct pressure over the head of the bone; the application of a plaster-of-Paris dressing according to the principles advised for reduction; and even keeping the patient in the horizontal decubitus for the necessary period of six or eight weeks—all these have been tried and have proven ineffectual. My preference is for a carefully applied figure-of-8 bandage, with compression over the head of the bone, to be maintained for six or seven weeks, and with the elbow secured in proper position by means of a sling and bandage confining the arm to the chest. I believe that this plan of treatment will afford the greatest certainty of restoring a fair degree of functional activity while at the same time fulfilling the other indications and contraindications. In the case of a young female, we might be justified, for the sake of preventing any deformity, in keeping the patient on her back for the necessary length of time, her general condition being carefully watched during this period.

Backward dislocations may be caused by a direct force acting near the sternal end, but not of sufficient strength to produce a fracture; or they may result from a force acting indirectly upon the posterior and outer surface of the shoulder. In this form of dislocation the end of the clavicle may be found below and behind the sternum or slightly above it; the shoulder may drop forward, and the displaced end of the bone may press upon the trachea or upon the esophagus, thus producing dyspnea or dysphagia, together with pain more or less severe in the locality. In some instances there may also be a partial arrest of the circulation in the arm, due to pressure on the subclavian artery.

In order to effect a reduction the shoulder must be carried upward, outward, and backward, and the parts may then best be maintained in this position by keeping the patient on the back with a firm cushion beneath the shoulders; or a bandage may be applied in the manner suggested for the relief of a dislocation of the clavicle forward—no compress, however, being needed. This form of dislocation is not only readily reduced, but the parts can more easily be maintained in the desired position than in the case of the other variety. The restoration of function may be complete, although some deformity is likely to remain.

Dislocation upward of the sternal end of the clavicle is almost universally caused by a force operating on the end and top of the shoulder, throwing it inward and downward and causing the inner extremity of the clavicle to be torn from its attachments by the leverage exerted from the acromial end. When such an accident happens, not only the capsule with the ligaments closely investing it, but in some instances the costoclavicular ligament and some fibers of the subclavian muscle are ruptured. In this form of dislocation the shoulder appears to be depressed, and the sternal end of the clavicle is so lifted as markedly to increase the space between it and the first rib. The suprasternal fossa is encroached upon, there is a diminution of the acromiosternal distance, and the head of the bone, protruding between the sternal attachments of the sternocleidomastoid and the sternohyoid muscles, may pass beyond the middle of the sternum and may overlie the sternoclavicular junction of the opposite side. The sternal portions of the sternocleidomastoid muscles on both sides may be raised and rendered tense by the pressure of the bone from behind.

"Reduction may be found easy," says Hamilton, "but Malgaigne thinks a perfect result is impossible—at least it does not seem to have been accomplished in any of the cases reported." Yet farther on he says: "In no case did the displacement seriously impair the functions of the arm."

In the *Treatment* of this variety of dislocation the arm should be drawn upward and outward, while at the same time the head of the clavicle is pressed down into the articular cavity. Maintenance is

secured by drawing the shoulder back with a figure-of-8 bandage, placing a heavy compress in the axilla, and securing the elbow to the chest. As a further aid, a compress should be placed over the head of the bone, and upon this there should be brought to bear a force acting in a downward direction. If these measures fail, and if the necessities of the case demand it, from either a functional or a cosmetic standpoint, the joint may be opened and the head of the bone strongly wired to the sternum.

An important point to be considered in these dislocations is the strong necessity of preventing movement of the dislocated end of the bone—a task which is rendered specially difficult by the nature and position of the joint and by the constant movements of the body and arm. Furthermore, if the case is one in which the question of deformity may be set aside, it is better to aim at securing the restoration of a reasonable degree of functional activity and not to undertake too heroic or violent measures for relief. As a rule, all efforts to secure reduction of the dislocation should be limited to a quite early period, and the danger of injuring important subjacent tissues and vessels must be kept constantly in view.

In dislocations of the *Acromial end of the clavicle*, it is deemed necessary to consider only three varieties, viz., one in which the end of the clavicle is lodged above the acromion, or upward; another below it, or downward; and the third, below the acromion and coracoid processes—the subcoracoid variety of dislocation of the clavicle.

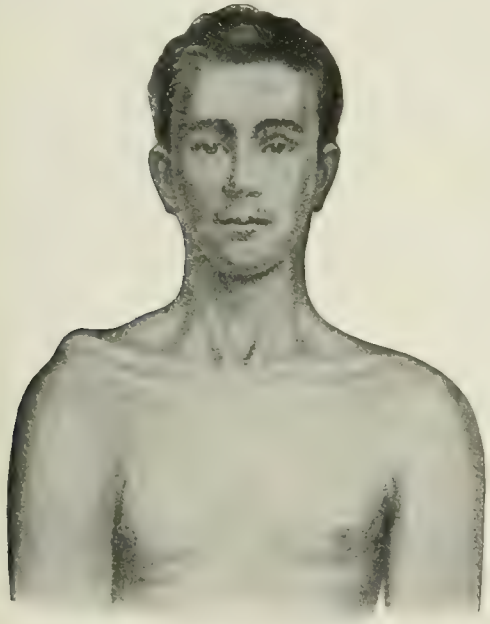

Fig. 1725.—Upward Dislocation of Acromial End of the Clavicle. (Helferich.)

In *upward dislocation* we find drooping of the shoulder and a prominence produced by the end of the clavicle projecting above the acromion. With these conditions are associated pain and a greater or lesser degree of difficulty in using the arm. The dislocation may result from "force acting directly upon either the scapula or the clavicle," as happens very frequently.

*Treatment.*—The reduction is usually effected quite readily by pushing the head of the humerus upward, and at the same time making downward and slightly lateral pressure on the end of the clavicle. If the dislocation has taken place in an outward direction, the shoulder should be carried well backward, or outward and backward; or a pad should be placed in the axilla and the arm should be used as a lever, proper pressure being made at the same time upon the displaced end of the clavicle.

The maintenance of the joint in its natural position, after reduction, is a more difficult task to accomplish, owing to the fact that the weight of the arm, acting in conjunction with the contraction of muscles, drags the shoulder down, while at the same time the contraction of the trapezius lifts the clavicle up. A variety of suggestions have been made as to how the purpose desired may be accomplished. Among them may be mentioned the following: most of the dressings used to correct fracture of the clavicle;

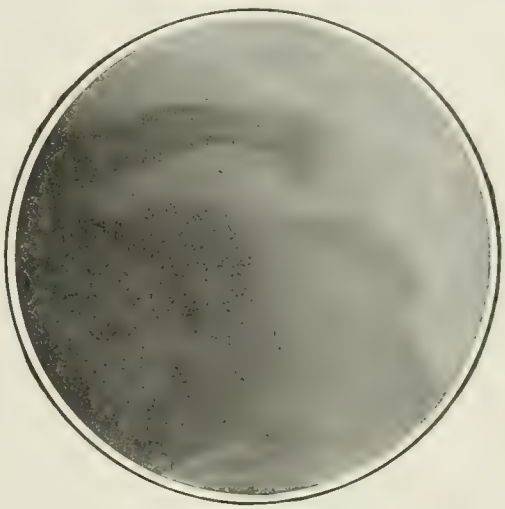

Fig. 1726.—Dislocation Upward of the Distal End of the Clavicle. (Rixford in Am. Practice of Surgery.)

simple bandages passed over the shoulder and under the elbow; immovable plaster or other dressings; pads, straps, etc., in varying combinations; the ordinary Petit's tourniquet (well padded) placed over the end of the clavicle with the strap passing under the elbow; and Mayor's apparatus. All these have been tried, each one giving good results in some cases and failing in others. Sayre's dressing for fractured clavicle is about the simplest and most reliable. Many surgeons, however, advocate warmly Stimson's method of treating this dislocation. This is accomplished by means of a long strip of adhesive plaster, three inches wide, the middle point of which is placed over the front of the flexed elbow, and the ends carried up in front of and behind the arm, crossing over the distal end of the clavicle and then being fixed to the front and back of the chest, while the bone is held in place by pressure over the elbow and clavicle. The forearm is supported by a sling and the arm is bound to the chest. The readiness with which an inspection can be made from time to time, so that a recurrence of the dislocation may be quickly detected, is a good feature of this method. On the other hand, the possibility of sloughing at any time at the point of the elbow must be watched for and prevented. Gross first suggested wiring with strong silver wire, and this was tried by Cooper, of San Francisco, and by Dr. Hodgen, of St. Louis, in two cases. Although in these two cases the procedure proved successful, Hodgen said that he would not repeat the operation except in cases of *very great* displacement. Mayor's apparatus consists of a sling or casing for the forearm, with straps and buckles attached to the covering over the point of the elbow posteriorly; one of the straps passing over

a compress placed over the distal end of the clavicle and attached to the casing in front of the elbow, the other passing over the sound shoulder and attached to the casing midway between the elbow and wrist.

Dislocation of the *acrominal end downward* is exceedingly rare, only five cases having been cited by Hamilton; while Stimson[5] gives a total of twelve. So far as known, this dislocation is caused by direct violence forcing the end of the clavicle downward. At the same time the lower angle of the scapula moves slightly outward, and the coracoid process is depressed —thus saving it from being snapped off. The acromioclavicular, coracoclavicular, and coracoacromial ligaments are ruptured, and the head of the clavicle rests on the capsule of the shoulder-joint and beneath the acromion. The alterations and symptoms produced are the following: There is a marked depression at the point of dislocation; the acromion is usually prominent, and a groove or gutter may be felt along its inner border; the displaced clavicle can be detected beneath the acromion; while the arm may be moved by the surgeon pretty freely backward or forward, the patient is unable to lift the arm voluntarily; and, finally, there is more or less sharp pain, increased on movement of the limb.

*Treatment.*—The reduction is readily accomplished by drawing the shoulders outward and backward; the position being maintained by securing the base and lower angle of the scapula snugly and firmly to the body by a broad bandage and compress, while a sling is employed for supporting the arm in the desired position. These dressings are to be worn for six or seven weeks. The coracoid process prevents the bone from slipping out of its place so long as the scapula is maintained in the position suggested.

*Subcoracoid dislocation* is yet more rare than any of the other varieties; the single case reported by Pinjon, and the five cases by Godemer of Mayenne, being all that so far have been cited. Hamilton is sceptical as to the existence of this form of dislocation. I quote the following from Wharton and Curtis[4]: "It is said to result from the shoulder being forced upward, outward, and backward, while at the same time the acromial end of the clavicle is driven downward. The most marked symptoms are: unusual prominence of the acromion and coracoid processes, pain and restricted motion of the arm, and an increase of the distance between the sternum and the summit of the shoulder.

*Treatment.*—To reduce this displacement the arm should be flexed and brought to the side and carried forcibly upward, inward, and backward, to relax the clavicular portion of the pectoralis major muscle. The clavicle should be grasped and disengaged from its position below the coracoid process and pressed back into its proper position. After reduction a Velpeau's bandage should be applied and the dressing retained for six or eight weeks."

Dr. E. M. Moore, in his article in the first edition of this work, places great confidence in his method of dressing a dislocated clavicle, and bases this confidence on the results obtained in sixteen cases which occurred partly in his own practice and partly in that of his friends, two of these cases being luxations at the sternal end. I quote from his article as follows: "The simple bandage which is here illustrated subserves the purpose with great assurance of success. This, as will be shown by the cuts, consists of the application of a shawl, or, what is better, a piece of common cotton cloth, about two and one-fourth yards in length, and a yard or so in width, folded like a cravat until it is about eight inches in breadth at the center. The application of this bandage is conducted in the following manner: Place the bandage, thus prepared, upon the palm of the outstretched hand, with the finger and thumb in the line of its length and at its center. This enables the surgeon, while placing it under the elbow of the patient on the affected side, to grasp it firmly, and so to adjust it that the border reaches about two inches up on the humerus, and about six inches down on the forearm. The grasp of the surgeon's hand retains the bandage in position during the succeeding manipulations. The first movement is to place the inner tail up over the shoulder, smoothing it out over its rounded surface, and then committing it to an assistant. The outer tail is now carried over the forearm, up behind the back to the top of the opposite shoulder. Traction is now made upon this tail so as to draw the elbow backward and toward the thorax, after which its end is brought over the shoulder and under the axilla of the unaffected side. The other tail is now seized, and when made tense it draws the shoulder backward. This is carried under the armpit, and over the point of the unaffected shoulder. The two ends are now secured by pins at the points where they overlap the bandage. This, as will be observed, produces the peculiar form upon the unaffected side known as the figure-of-8 bandage. The special twist around the elbow of the affected side is similar in form, although one end runs up over the shoulder. For these reasons the writer has called the bandage 'the figure-of-8 from the elbow.' The bandage, however, is not complete without a sling to hold the forearm slightly above the horizontal position while the patient is erect. If the forearm droops, the bandage becomes disengaged from the elbow, and the arm has a tendency to swing forward. But if it be placed in the position already indicated, its weight has a tendency to carry it backward. This sling is best constructed by placing a strip of cotton cloth, three or four inches wide, around the wrist, and pinning the two ends together upon the larger bandage as it passes

Fig. 1727.—Figure-of-8 Bandage from the Elbow. Side view.

Fig. 1728.—Figure-of-8 Bandage from the Elbow. Front view.

over the shoulder. It is desirable, also, to fold the end that projects behind the elbow and secure it with a pin, so as to make a sort of cup which will hold the elbow in its place. This bandage is usually worn with great comfort to the patient, the points most complained of being the axillary border of the unaffected side and the extremities of the olecranon and condyles of the elbow held by the bandage.

"Protection against this pressure can be afforded by little compresses, placed alongside the suffering points, and can be left entirely to the management of the patient. It is wise, however, to watch him daily for the period of a week, loosening the tails of the bandage and then tightening them a little. At the end of this time the capacity of stretching will have

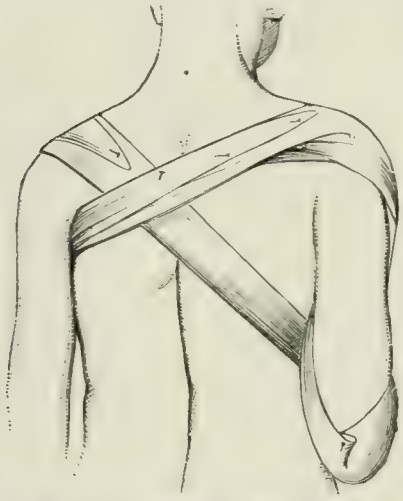

Fig. 1729.—Figure-of-8 Bandage from the Elbow. View from behind.

ceased." Dr. Moore further states that the dressing will have to be kept on for about two weeks, and he claims for it "better results than by any other method, as meeting more definitely and more practically the exigencies of this condition."

Dislocations of the Scapula.—The inferior angle of the scapula, though somewhat rare, may become displaced. The latissimus dorsi, or a portion of it, may slip beneath the lower end of the bone—an accident which generally occurs in children as a result of lifting them by one arm. The effects produced are: Pain and difficulty in moving the arm, and a marked projection of the lower end of the bone, which is increased if the arm is drawn forward. Reduction under these conditions may be impossible.

Dislocations of the Shoulder-joint comprise fully one-half of all dislocations; some observers even placing the proportion a little beyond this. On this account alone they constitute the most important class. Quite a number of varieties have been described, but the following table gives all that it is necessary to consider; others being but modifications of these, or secondarily assuming one of these forms, either accidentally or by manipulation.

*Varieties of dislocations of the shoulder-joint.*

| | |
|---|---|
| 1. Downward | Subglenoid (common). |
| | Erecta (very rare). |
| 2. Forward | Subcoracoid (common). |
| | Subclavicular (rare). |
| 3. Backward | Subspinous (rare). |
| | Subacromial (rare). |
| 4. Upward | Supraglenoid (rare). |

In the *Subglenoid dislocation* we find the capsular ligament extensively torn on its under surface, permitting the head of the humerus to leave the glenoid cavity and take a position on the anterior edge of the scapula immediately below the glenoid cavity. The tendon of the long head of the biceps may be ruptured or completely detached from its insertion; the supraspinatus is stretched or lacerated; the infraspinatus, coracobrachialis, and subscapularis are put upon the stretch, the latter sometimes torn from its attachment to the head of the humerus; the deltoid is placed in a condition of extreme tension, and paralysis of this muscle may be among the unpleasant sequelæ. The artery and vein may be injured, and the circumflex and other nerves may be seriously impaired.

Among the more frequent *causes* the following may be cited, in the order of their frequency: (*a*) a force applied to the upper end and outer surface of the humerus; (*b*) a fall upon the extended hand; (*c*) a fall upon the elbow. Sudden contraction of the muscles while the arm is strongly abducted may produce this luxation. It is perhaps one of the most frequent dislocations produced spontaneously, abduction of the arm favoring its production.

Among the most prominent conditions and *symptoms* that result from this dislocation may be mentioned the following: the presence of a depression under the end of the acromion; the elbow is carried out from the body a distance of three or four inches and a little backward; it cannot be made to touch the lateral surface of the body; the line of the axis of the limb is directed to the axilla, and decidedly below the glenoid fossa, which will be found empty; the head of the humerus can usually be felt in the axilla, especially when the limb is carried away from the body —Dugas' sign; inability to touch the opposite shoulder on top with the palm of the hand while keeping

Fig. 1730.—Subglenoid Dislocation. (Traced from a photograph taken twenty-three hours after the injury had been received.)

the elbow in contact with the chest; the outer surface of the arm presents two planes which are inclined toward each other and which meet at the insertion of the deltoid muscle; numbness of the arm and generally pain, especially when the attempt is made to bring the elbow to the side; possibly free passive motion, yet the elbow cannot be brought into contact with the side without great pain, which is doubtless due to pressure of the humerus on the axillary plexus. The existence of these symptoms, or of a majority of

them, immediately after luxation, should make it possible to arrive at a correct diagnosis.

Ordinarily, if the force producing the luxation has not been extreme, and reduction has been accomplished at a reasonably early period without a resort to excessive force or violence, which should ever be guarded against, complete recovery may confidently be expected in a comparatively short period of time.

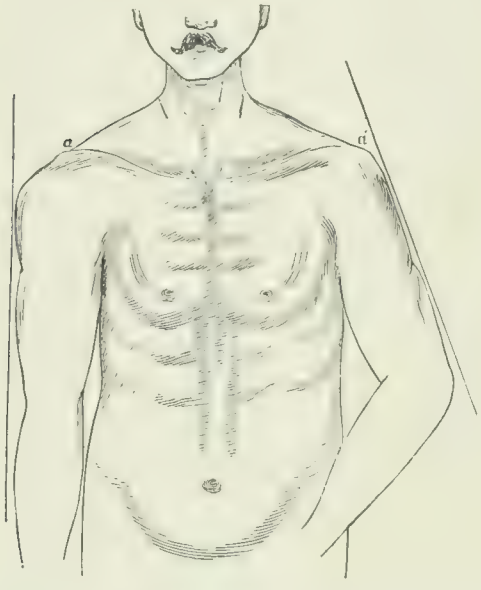


Fig. 1731.—Subglenoid Dislocation of the Humerus, Showing Flatness Beneath the Acromion. *a*, *a'*, Tips of acromion processes. The ruled lines indicate the test for dislocation by means of a straight-edge line on the arm.

Yet the character of the injury producing the dislocation, and the absence of swelling, or the presence of only a slight degree of swelling, are not always indicative of the amount of damage sustained by important tissues in the immediate vicinity of this joint. The extensiveness of the swelling may be the result of grave injury to important blood-vessels, or, on the other hand, it may be due to the fact that the individual is predisposed to serous, fibrinous, or hemorrhagic effusion. In the case of a slight injury to the main trunk of the nerves or to some terminal branch, the pain may not only be great but it may appear at an early stage, and we may have in addition temporary loss of muscle functions. On the other hand, more serious nerve lesions may manifest themselves at quite a late stage, and, besides, they may be slow in attaining any marked degree of prominence. It is extremely difficult to say exactly how much injury muscles, nerves, tendons, or vessels have sustained, or to predict to what extent restoration of function may take place. I have gone somewhat fully into these points as affecting this particular variety of dislocation of the shoulder, yet they play a more or less important part in all forms of dislocation, and especially so in all the forms of dislocation of this important joint.

*Treatment.*—The late Prof. Moses Gunn of Chicago, in a paper read before the American Surgical Association in 1884, regarded the upper and untorn portion of the capsule to be the chief obstacle in the way of reduction and he suggested the following: "The patient sitting on the floor, the arm is carried to an angle of 45°, and entrusted to an assistant, the surgeon placing his hands on the shoulder with the tips of the fingers resting on the head of the humerus in the axilla. The assistant making upward and outward traction, the head glides into place guided and followed by the fingers of the surgeon; and the arm is lowered to the side, tension being kept up during this movement."

Sir Astley Cooper's method of placing the heel (divested of boot or shoe) in the axilla, where it acts partly as a wedge, forcing the head of the bone from the edge of the scapula, and partly as a fulcrum as well as a counterextending force, will in many instances prove effective. In this procedure the forearm of the patient is to be flexed at a right angle with the arm, and both traction and a slight rotary movement are to be exerted upon the limb by the surgeon, who must be seated by the side of the recumbent patient. Sir Astley Cooper also in some cases substituted the knee for the heel in the axilla. With the patient seated in a low chair, the surgeon, having placed his foot in the chair beside the patient, brings the axilla over the knee; then, steadying the acromion and scapula with one hand, he presses the lower end of the humerus downward with the other.

In Prof. Nathan R. Smith's method counterextension is made from the wrist of the opposite side; the patient being seated in a chair, while the surgeon, with his foot on the chair and knee in the patient's axilla, employs manipulation and extension by means of the injured arm, the extension being aided by traction on the wrist on this, the affected side, by an assistant.

La Mothe's method consists in pulling the arm directly upward, while at the same time pressure is made downward over the shoulder-joint. According to Hamilton, Jobert succeeded by means of this method after twenty-three days, "when all the usual methods had failed."

Skey's method is by the application of a padded knob of iron in the axilla, with two strong, straight branches extending laterally, and terminating in a bulb or ring by means of which counter-extension may be maintained. Extension is effected by compound pulleys.

I regard Kocher's method as the best, not only for this dislocation, but also for the subcoracoid and subclavicular varieties. He flexes the forearm upon the arm; carries the elbow against the side of the body; abducts the hand, in order to rotate the head of the humerus outward until resistance is experienced; then he carries the elbow forward, upward, and slightly inward, while the arm is still flexed at a right angle and the hand maintained in a position of forced abduction; and finally he rotates the arm

Fig. 1732.—Dislocation Upward of the Distal End of the Clavicle. (Rixford, in Am. Practice of Surgery.)

inward and carries the hand up on to the sound shoulder. All of these movements are to be executed slowly and as gently as possible. According to this method, while the elbow is flexed at a right angle and pressed closely to the side of the chest, the forearm

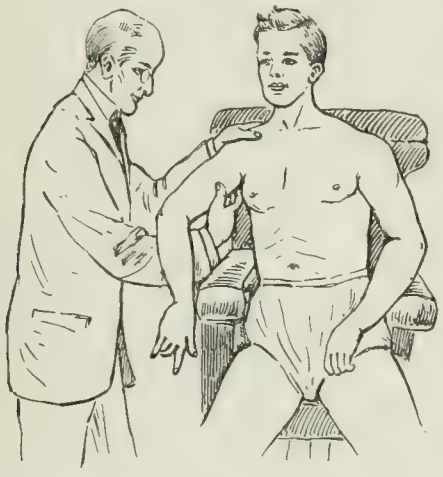

Fig. 1733.—Direct Reposition of Dislocated Humerus.

is turned as far as possible away from the chest, thus causing the arm to rotate externally. If, during the movement just described, the head of the humerus does not roll outward and in front of and below the acromion, the attempted reduction will

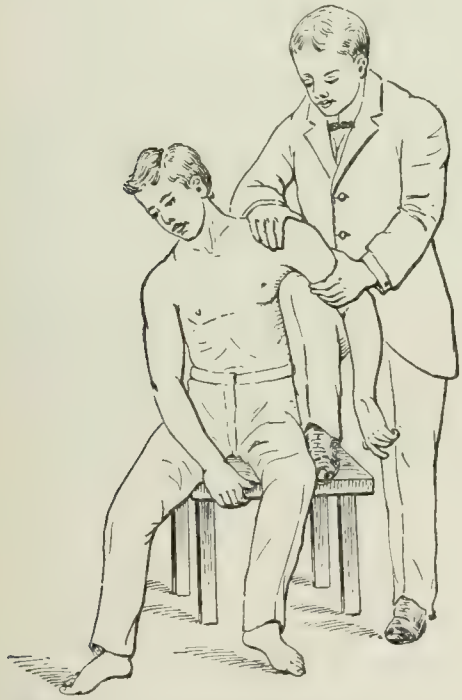

Fig. 1734.—Reduction of Dislocated Humerus, with Knee in Axilla. (Cooper's method.)

fail. While external rotation is being accomplished the elbow should be carried well forward and upward, the arm next rotated inward, and finally the elbow lowered. During the latter part of these manipulations an assistant may render good service by pressing the head of the bone outward with his fingers or by pulling it outward by means of a hand introduced in the axilla.

The after-treatment of this, as of the other dislocations of the shoulder, consists in bandaging the arm closely to the side of the body with a four-tailed bandage for about ten days or two weeks, while the wrist itself is to be carried in a sling. At the end of this time passive motion may be commenced, and the patient may be allowed gradually to resume the use of the arm, which must still be carried in a sling for a week or two longer. Violent movements must carefully be guarded against.

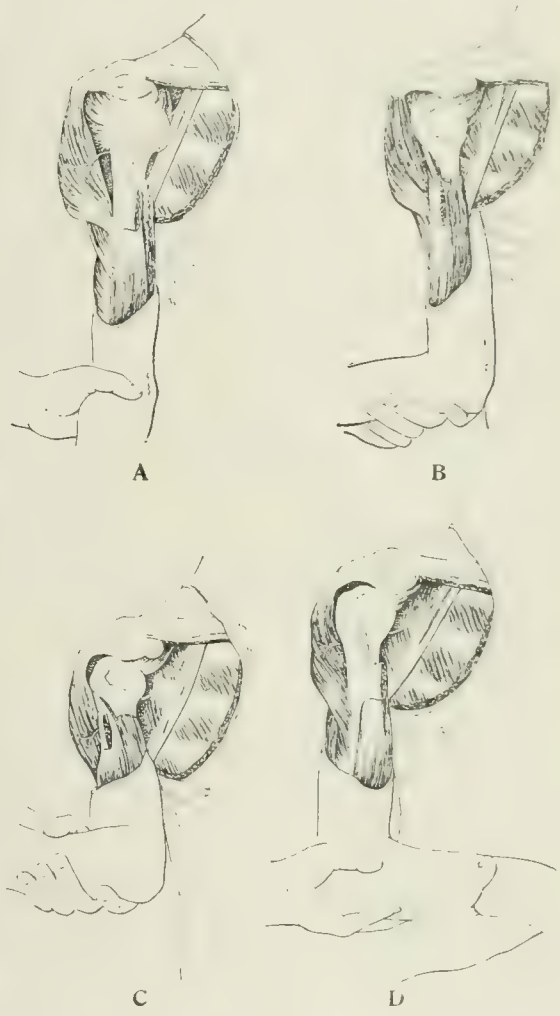


Fig. 1735.—Kocher's Method of Reducing Subcoracoid Dislocation of the Humerus. *A*, First step; adduction of the arm until the elbow comes in contact with the trunk; *B*, second step; outward rotation of the adducted arm by means of the forearm flexed at right angles; *C*, third step; elevation of the arm held in adduction and outward rotation; *D*, fourth step; inward rotation completing the act of reduction. (Helferich.)

*Dislocatio erecta* is among the rare dislocations at the shoulder. In this condition we have the arm held vertically with the hand on top of the head, in order to avoid the intense pain which arises when it is held in any other position. The mechanism of this dislocation seems to be this: while the arm is extended forcibly and is also elevated, a blow descending on or near the proximal end of the humerus drives the head of the bone downward. It is usu-

ally readily reduced by making firm traction upward, with manipulation on the head of the humerus, and then bringing the arm down to the side as the bone glides into position. This variety of dislocation occurred in a case which came under my observation. A boy, falling from a tree, with his right hand extended, caught hold of a lower branch and thus to some extent broke the force of the fall; but by this act he threw the head of the bone down below the glenoid cavity.

Fig. 1736.—Simple Apparatus for Keeping the Arms at Rest After Reduction of a Dislocation of the Humerus. (Helferich.)

*Subcoracoid luxation* embraces three-fourths of all the shoulder-joint luxations. It may be *caused* by direct force driving the head of the humerus forward and inward or by indirect force, such as falls upon the hand or elbow. In this dislocation the head of the bone lies against the anterior surface of the neck of the scapular, below the coracoid process. The head of the bone is above the tendon of the subscapularis muscle.

*Subclavicular luxation* is very rare. It is caused by the same sort of violence which produces subcoracoid. The head of the bone rests upon the thorax, below the clavicle, and underneath the pectoralis major muscle.

*Treatment.*—Reduction is by manipulation or the plans already given for subglenoid dislocation. The downward and forward dislocations are subject to the same plans of manipulation. Kocher's method is especially suited for the subcoracoid variety. The head of the bone rests beneath the spinous process of the scapula.

Fig. 1737.—Typical Subcoracoid Dislocation of the Humerus. (Helferich.)

*Subspinous Dislocation.*—These dislocations are produced most generally by a force acting directly on the anterior surface of the shoulder. If the subscapularis is not torn the humerus cannot be rotated outward.

Fig. 1738.—Subcoracoid Dislocation of the Right arm. The axis of the humerus is shown on both sides by the black lines. (Helferich.)

*Treatment.* — For the reduction of this dislocation the following plans have been suggested: Slight forward traction (Duplay); direct pressure on the head of the bone, with slight extension (Mollière); traction at a right angle with the body, with moderate rotation (Desprès); raising the hand and arm and turning the hand backward behind the head (Sir Astley Cooper); moderate traction downward and outward, with pressure directly on the head of the bone (Hamilton); and, finally, traction outward, downward, and slightly forward (Parker), the shoulder being fixed by the hands of an assistant or by other means. The plan of Dr. Moses Gunn of Chicago was to have the shoulder properly fixed by an assistant, while the surgeon, taking the limb by the elbow and forearm, raises it to a horizontal position, carries it to the front, rotates it inwardly, and draws it into place.

Without fracture of the acromion or coracoid process, upward dislocation of the humerus seems wellnigh impossible, yet it has occurred in very rare instances. The symptoms consist in the absence of the humerus from the glenoid cavity and its being found in the interspace between the coracoid and acromion processes, in front of and above the level of the clavicle. In Albert's case, cited by Stimson, both shoulders were dislocated. The patient, a full-grown man, while holding on to the reins of a pair of runaway horses, was dragged at full length on the ground. The deformity, which consisted of a prominence on the front and upper part of the shoulder, was more conspicuous on the left side than on the right. Stimson gives the following points in the symptomatology of this form of dislocation: "The limb hangs by the side, perhaps slightly abducted, and rotated outward; its axis is directed from below upward and forward, passing in front of the normal position of the head." "Voluntary movements," he says farther on, "are almost or quite impossible, and passive movements are greatly restricted, in old as well as recent cases."

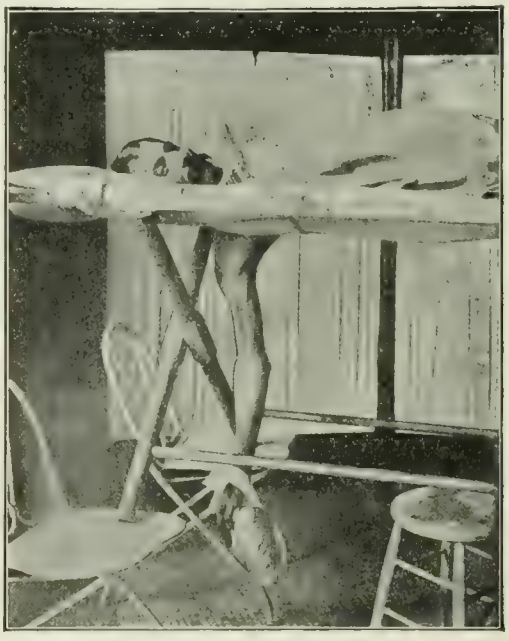

Fig. 1739.—Stimson's Method of Reducing a Dislocation of the Shoulder.

The following methods of reduction have been suggested: Traction downward, under anesthesia, combined with a tilting motion which brings the head of the bone back toward the glenoid cavity (Verneuil); carrying the arm away from the body until the head passes under the coracoid process, and then at the same time raising the elbow and rotating the humerus inward (Panas); abduction, extension backward, and rotation inward (Albert).

According to some observers there have been cases of partial dislocation of the shoulder in which, after rupture of the long head of the biceps, the contraction of the supraspinatus muscle has drawn the head of the bone almost, but not entirely, out of its normal posi-

tion. Such a partial dislocation is marked by the presence of a depression on the posterior aspect of the joint, beneath the acromion, and by the existence of an unnatural rounded prominence formed by the head of the bone in contact with the coracoid process. Hamilton,[2] and Gerster,[6] however, entertain strong doubts in regard to the occurrence of such a partial dislocation.

An easy method of reducing dislocations of the shoulder has been suggested by Dr. Lewis A. Stimson.[7] It is thus described by him (Fig. 1739): "The patient is upon a canvas cot, with the injured arm hanging through a round hole made in the middle and about eighteen inches from the end. The cot is raised to a sufficient height from the floor, and a ten-pound weight is fastened to the wrist of the dependent arm. Reduction is accomplished in a few minutes and without pain. It has been tried in ten cases, and has never failed, six minutes being the longest time required."

Dislocation of the shoulder complicated with fracture is not unfrequently met with; the break usually occurring at the surgical neck. As preternatural mobility, crepitus, etc., accompany the signs occasioned by the presence of the head of the bone in its abnormal site, the diagnosis is not difficult. When the fracture occurs at the anatomical neck it is not always possible to make the diagnosis certain unless a very careful and thorough investigation is made. If the head of the bone cannot be restored to the glenoid cavity by reasonable manipulation of this fragment alone—the arm affording no assistance—it will probably be best to wait four or five weeks until union has taken place, and then to make efforts at reduction. It must be remembered, however, that under these circumstances there is very great danger of refracturing the bone, and consequently proper precautions, such as firmly but temporarily applying splints, bandages, etc., must not be neglected. McBurney effected reduction in one case by cutting down through the deltoid upon the lower end of the fragment, drilling a hole into it, and inserting into this hole a right-angled hook, by means of which he made forcible traction and rotation of the fragment. The propriety of removing the head of the bone will in some instances require consideration, and the operation may be necessitated in irreducible cases, if great suffering and inconvenience exist.

Dislocations of the Elbow-joint are next to the shoulder in frequency and are most common in children. Both bones or only one may be dislocated.

*Dislocation of both bones backward* is caused by falls upon the extended hand or by twist inward of the ulna.

Symptoms.—The coronoid process lodges in the olecranon fossa of the humerus; the olecranon is very prominent; the forearm is flexed, supinated, and shortened; the lower end of the humerus projects in front of the joint, but below the crease in front of the joint; and the head of the radius can be felt back of the outer condyle.

Supracondyloid fracture at the base of the humerus is often mistaken for this dislocation, but a careful examination will show that in fracture there is no shortening of the forearm; that the projection in front of the joint is sharp and not smooth and is above the skin crease; the forearm, while more or less flexed, is pronated; or midway between pronation and supination; and there is no alteration of the relation of the olecranon process and condyles.

Treatment.—It is very important to reduce this dislocation as soon as possible on account of the great swelling that takes place soon after the injury and that greatly embarrasses reduction. If reduction is not accomplished, it means a useless member, for the powers of flection, pronation, and supination are lost.

The best plan is to grasp the patient's wrist and place your knee in front of the elbow-joint, press with your knee upon the bones of the forearm and not the lower end of the humerus, then flex the forearm with considerable force around the knee. One can use in any other way forced flexion, traction, and extension.

The forearm should be immobilized for two weeks in a right-angled position by a four-tailed bandage and sling, and passive motion should begin at the end of a week. If the patient is a very young child, Jones's position had best be employed for ten days or two weeks.

*Dislocation of Both Bones Forward.*—The cause is a blow or fall on the olecranon when the forearm is flexed on the arm.

Symptoms.—The olecranon is on a level with the humeral condyles; the forearm is flexed and lengthened; and the general symptoms are deformity and loss of function.

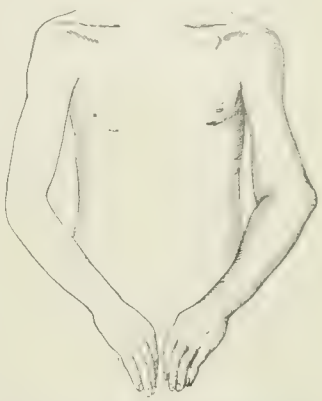

Fig. 1740.—Backward Dislocation of Both Bones of Left Forearm, Showing Prominence of Olecranon and Shortening of Forearm. (Helferich.)

Treatment.—Forced flexion with slight extension will, when employed soon after the injury, always accomplish reduction. It is important in this dislocation to make passive motion daily after the first week. The limb should be immobilized as in the backward dislocation.

*Dislocations of both bones of the forearm laterally* are usually incomplete. The cause is direct force operating in the opposite direction from the displacement.

Symptoms.—In either the outward or inward dislocation, the forearm is flexed, fixed, and pronated; the joint is widened. In the outward variety the head of the radius projects externally and has a depression above it, and in the inward variety the ulna projects internally making the external condyle very prominent.

Fig. 1741.—Dislocation of Both the Radius and the Ulna Inward.

Fig. 1742.—Dislocation of Both the Radius and the Ulna Outward.

Treatment.—Reduction is accomplished by making

extension of the forearm and pressure on either the displaced ulna or radius, by means of a soft pad in the opposite direction to the displacement. Immobilization had best be enjoined for at least three weeks and passive motion begin after a few days, increasing it each day for at least two weeks after the bandages are removed.

*Dislocation of the ulna alone* is very rare and can take place in only one direction—backward. The cause is the same as that of backward dislocation of both bones of the forearm.

Symptoms.—The forearm is flexed, fixed, and pronated. The head of the radius is found in place and the olecranon projects posteriorly.

Treatment.—Same as for dislocations of both bones.

*Dislocation of the radius forward* is quite frequent and is caused by a fall on the hand when the forearm is pronated and extended, or by a fall or blow on the back of the joint.

Fig. 1743.—Dislocation of the Ulna Backward, without the Radius.

Symptoms.—The forearm is midway between pronation and supination and flexed. The head of the radius is found in its new location and ordinary efforts to supinate the forearm are impossible.

Treatment.—Reduce by flexing the forearm over the knee, while at the same time make extension or traction and efforts at full supination. The deformity tends to recur after reduction because of rupture of the orbicular ligament. The after-treatment is the same as that of the other dislocations of the elbow. Some surgeons advise an open operation.

*Dislocations of the radius backward* are caused by falls on the hand or by blows on the front of the joint.

Symptoms.—The forearm is flexed, fixed, and pronated and the head of the radius can be felt behind the outer condyle.

Treatment.—Reduction is effected by flexion and extension. Immobilize with a four-tailed bandage and begin passive motion at the end of the first week.

*Dislocation of the radius outward* is very rare. The head of the bone can be felt in its new situation and the cause and treatment are the same as when both bones are dislocated outward.

*Subluxation of the head of the radius* is caused by traction upon the hand or forearm by lifting, and as it occurs in young children it often results from the mother or nurse lifting the child by the arm over the gutter in the streets or to save it from a fall. Various causes are claimed for its production other than the above.

Symptoms.—Pain is very great in the elbow and sometimes runs down the forearm. The position of the forearm is usually slight flexion and midway between pronation and supination. Pressure over the head of the radius is very painful, and so are attempts at flexion and extension of the forearm, and the movements are restricted, especially supination. It is believed by most surgeons that in the majority of cases the tuberosity of the radius is locked behind the inner edge of the ulna; or that there is a slipping up of the margin of the orbicular ligament over the rim of the head of the radius.

Treatment.—Ordinarily the dislocation is easily reduced by placing the forearm at right angles to the arm and making forcible supination. Apply an anterior angular splint or use Jones's position for a week or ten days, and begin passive motion in four or five days.

In *dislocations at the wrist* we may have the ulna detached from the semilunar surface of the radius and displaced forward or backward. If forward, it is the result of violent supination of the hand, and is accompanied by rupture of the anterior ligaments of the joint. Somewhat to the radial side and on the palmar surface of the wrist a prominence will be apparent, and that of the lower end of the ulna at the back of the wrist will be wanting; the hand will be supinated. With the forearm flexed, counter-extension should be made from the arm, and extension should be applied to the hand. At the same time pressure backward should be made over the head of the ulna, whereupon firm pronation will enable the ulna to slip back into position. Two well-padded splints, such as are used in fracture of both bones of the forearm, should be worn for at least four weeks.

*Backward displacement of the ulna* is the result of extreme pronation of the hand. The ordinary ulnar prominence at the back of the wrist will be found in this dislocation to be much more conspicuous, and the styloid process will no longer be in line with the fifth metacarpal bone; the hand will be supinated and the fingers flexed. When the hand is extended, the bone is pushed back until it becomes re-engaged in the semilunar cavity of the radius. The after-dressing consists in applying to the bone a firm compress and a straight posterior splint for a period of three or four weeks; and then, after these have been removed, the wrist should be strapped with adhesive plaster, or a bandage and compress should be applied. These dressings should be worn for some time.

Carpus.—*Dislocation of both bones at the wrist* may take place in either an anterior or a posterior direction. The lesion is quite rare. When the wrist is extended violently and to an extreme degree, the anterior carpal and lateral ligaments are ruptured and the bones of the carpus forced back on the anterior surface of the radius. The hand will be fixed in an extended position, the lower end of the radius and ulna forming a prominence on the posterior surface of the wrist. By making extension from the hand and counterextension from the arm, and by extending the carpus on the forearm, at the same time pressing the ends of the radius and ulna forward, the luxation may be reduced. The hand and forearm should be placed on a well-padded anterior splint, and secured by a roller bandage. These dressings should be worn for several weeks.

Fig. 1744.—Forward Dislocation of Carpus.

The application of force to the back of the hand in such a manner as to produce extreme flexion may cause rupture of the posterior radiocarpal and lateral ligaments, and force the carpus back on the posterior surface of the radius and ulna. The deformity consists in marked increase in the anteroposterior diameter of the wrist, the hand being slightly extended, the fingers flexed, and the joint immobile. With the forearm fixed, extension from the hand combined with slight flexion, abduction, and adduction, will effect a reduction of the dislocation. A straight splint, applied to the anterior surface of the forearm and hand, should be worn for several weeks.

In discriminating between a fracture of the wrist and a dislocation at this point we are aided by the following facts: in a fracture there is increased mobility with crepitus, and the deformity reappears after it has been reduced, provided no dressings are applied to keep the parts in place. In Colles' fracture,

there is alteration of the styloids while in dislocation the styloids are normal.

In compound dislocation at the wrist, the fragments of bone should be removed under rigid asepsis, all torn nerves, tendons, etc., should be sutured, bleeding vessels should be ligated, and a well-padded palmar splint should be applied.

*Dislocations of the carpal and metacarpal bones* are rare, and no specific instructions are likely to meet the indications in any particular case. A knowledge of the anatomical relations, comparison with the

Fig. 1745.—Backward Dislocation of Carpus.

uninjured hand, and general attention to practical surgical measures are the only things that are necessary. The displaced bones should be moulded into position with the fingers of the operator and properly secured in this position by a splint and bandage.

The metacarpal bone of the thumb may be dislocated backward or forward by extreme extension or flexion. The reduction is to be effected by making extension from the proximal phalanx and by pressing the displaced bone back into position. As a dressing a moulded binder's board or a leather or guttapercha

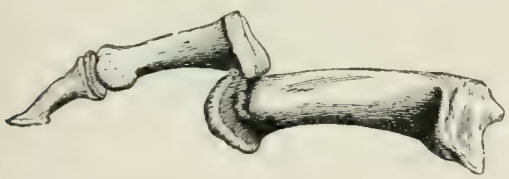

Fig. 1746.—Dislocation of First Phalanx of the Thumb Backward.

splint should be fitted to the thumb; it should extend well back over the wrist and should be secured by a narrow roller.

The thumb is dislocated most commonly by a backward or forward displacement of the proximal phalanx, the proximal end passing in front or back of the head of the metacarpus. As a rule, the backward dislocation is rendered more difficult of replacement by reason of the head of the bone being grasped between the two heads of the flexor pollicis brevis. In effecting a reduction the metacarpal bone should first be fixed, and then the thumb is to be extended, drawn downward, and suddenly flexed. If this fails, one of the heads of the short flexor may be divided subcutaneously. A dressing similar to the one just cited will be appropriate. Noty[8] suggests the following plan as having succeeded in backward dislocation of the thumb after other efforts have failed: "The hand flexed and forcibly pronated; the surgeon's two forefingers placed beneath the head of the metacarpus, and the thumbs applied to the dorsum of the phalanx at its base, pressure is made in opposite directions as the thumb is raised to a right angle."

Reduction of *dislocation of the phalanges* is not difficult, and is usually accomplished by firm extension and manipulation. In compound dislocations of the phalanges efforts to secure perfect asepsis are essential. If the bones are extensively comminuted, the removal of fragments, excision, etc., may be needed, and as in simple dislocations, a moulded binder's board, or a leather or guttapercha splint, should be applied.

Dislocations of the Pelvic Bones partake more of the nature of a fracture, and for their diagnosis a careful study of the relations of the various prominences and of the degree of mobility at the point of separation, usually suffices. In order to secure a satisfactory examination the patient should be placed on a firm, well-padded table or mattress. The treatment consists in manipulating the bones into position and in applying broad strips of adhesive plaster and a well-adjusted muslin roller; or a plaster-of-Paris dressing may be applied, and this should be worn for a month or six weeks.

The displacements of the coccyx, whether from fracture or from dislocation, present similar indications; and if, after they have been reduced, a redisplacement occurs, giving rise to discomfort or inconvenience, removal of the bone is the proper recourse.

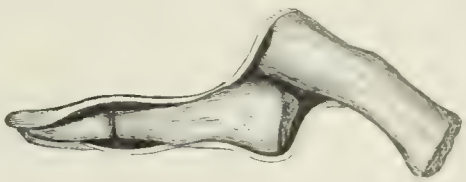

Fig. 1747.—Forward Dislocation of Second Phalanx of Finger.

Replacement is accomplished by means of the fingers of one hand placed in the rectum, while the other hand makes pressure from without.

Dislocations of the Hip, or coxo femoral dislocations, are liable to occur in one of four directions: (1) upward and backward on the dorsum ilii, (2) upward and farther backward into the ischiatic notch, (3) downward and forward into the thyroid foramen, and (4) downward and forward upon the pubes. In addition, what are known as irregular dislocations are occasionally met with, as diagonally between any of the above, and in some rare instances going beyond the thyroid foramen and lodging upon the tuberosity of the ischium. Slight manipulation, however, readily brings the head of the bone into one or the other of the four positions known as regular dislocations. Irregular dislocations are found only in cases in which the iliofemoral or Y-ligament is completely ruptured. If this ligament remains intact the head of the bone should be forced to take its position in one of the regular forms.

"In regard to frequency," says Hamilton,[2] "of 104 dislocations (regular), 55 were upon the dorsum ilii, 28 into the great ischiatic notch, 13 upon the foramen thyroideum, and 8 upon the pubes." They may occur at any period of life, but are found most frequently in the most active period, viz., from 15 to 45; and in regard to this matter I will quote the following

Fig. 1748.—Reduction of Backward Dislocation of First Phalanx with Clove-hitch.

tabular arrangement from Hamilton. He found in an analysis of 84 cases:

| | |
|---|---|
| Under 15 years | 15 cases. |
| 15 to 30 years | 32 cases. |
| 30 to 45 years | 29 cases. |
| 45 to 60 years | 7 cases. |
| 66 to 85 years | 1 case. |

The injury is more common in males than in females, Agnew giving 78 out of 89 cases, and Hamilton 104 out of 115. Continued fevers possibly predispose to dislocations of the hip, especially in the young. Double dislocations have been reported by numerous observers.

Dislocations upon the *dorsum of the ilium* comprise one-half of all hip dislocations. They are caused by a fall or a blow when the limb is flexed and abducted. Allis says rotation inward is the chief element in their production. Dislocations on the dorsum of the ilium are secondary to thyroid dislocations—muscular action shifting the bone.

*Symptoms.*—In dislocation upon the dorsum ilii, the limb is shortened from one and one-half to three inches, rotated inward, adducted, and slightly flexed upon the pelvis. During the examination the patient should stand erect, and should throw the weight of his body upon the sound foot, the knee touching the opposite thigh above or near the upper margin of the patella. The thigh can be flexed, but adduction is difficult, and abduction is impossible except to a very limited extent; the body is bent slightly forward; the roundness of the hip is diminished by relaxation of the gluteal muscles; the trochanter major is brought down so as to approach the level of the anterior superior spinous process; and the head of the bone may be felt on the dorsum ilii.

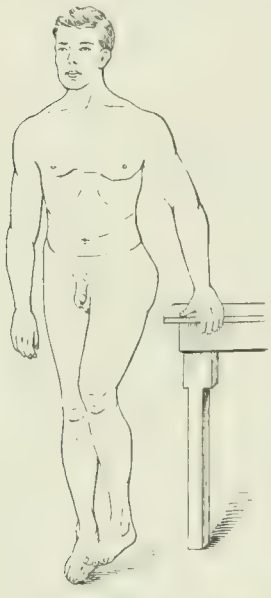

Fig. 1749.—Dorsal Dislocation of the Hip.

In differentiating this dislocation from fracture of the neck of the femur, we shall find absence of crepitus (unless fracture coexists), immobility, the toes turned in, a greater degree of shortening, and inability to stand upon the limb. It must also be borne in mind that a fracture is more liable to occur in advanced life; indeed it is quite rare in early life or prior to middle age. Separation of the epiphysis must be looked out for in early life, and the possibility of hip-joint disease must not be forgotten.

If the outer fibers of the iliofemoral ligament are ruptured, the rare form of everted dorsal dislocation may occur, in which we have the principal signs of a dorsal dislocation with the limb everted; the limb may be found inverted, but it is easily everted; and the foot may be slightly everted, lying flat upon the bed, or it may point backward. By flexion, rotation inward, and adduction this dislocation is readily converted into the regular form on the dorsum ilii.

In this dislocation, as with the others, the ligamentum teres is ruptured or torn from its attachment; the capular ligament is torn at its lower posterior portion, and generally also on its under part; the quadratus femoris, the gemelli, the obturator internus, the pyriformis, and obturator externus muscles. all or at least some are torn or partially lacerated. The glutei, on the other hand, either escape altogether or are only slightly injured.

The head of the bone may lie close to the acetabulum, even overlapping its cavity, or it may be lodged far backward, or backward and upward; it may be so low as to overlap both sciatic notches, its center resting on the base of the ischiatic spine or opposite the apex of the great sciatic notch.

When the head of the bone leaves the acetabulum at its lower part it usually passes below the obturator externus and then rises behind it, this muscle being interposed between it and the cavity; or lodging beneath this muscle it may press it forcibly upward; or finally, it may slip above the obturator internus, passing between it and the pyriformis, in which case it will be covered only by the gluteus maximus and the integument. In the latter event, the head of the bone can be felt in its new position, moving with the movements of the thigh; the normal outline of the buttock, which becomes broadened and prominent, is lost, and the great trochanter is approximated to the anterior superior spine, lying above a line drawn from that point to the tuber ischii (Nélaton's line). If the head of the bone is below the tendon the

Fig. 1750.—Dislocation on Dorsum Ilii Below Tendon of Obturator Internus. (Bigelow.)

symptoms will be practically the same, yet there is less shortening, and the flexion, adduction, and inversion are more marked.

*Treatment.*—Reduction is accomplished, in all recent cases, by manipulation. The studies of Dr. Bigelow have thrown great light upon dislocations at the hip, and he very correctly gives priority of invention of the method now so commonly in use to the late Prof. Nathan Smith, of New Haven, who formulated it in 1831. Desprès,[9] in 1835, independently formulated the method of flexion and outward rotation, and Reid,[10] in 1851, did the same. In his method, however, marked adduction preceded the flexion and the obstacles encountered were incorrectly attributed by him to the resistance of the muscles.

In reducing this dislocation by the classical method of Professor Smith, the patient is placed on a firm mattress and anesthetized (if deemed necessary); the surgeon grasps the ankle of the injured limb with one hand and the knee with the other; the leg is flexed on the thigh and the thigh on the abdomen; it is then adducted and carried to the sound side, and rotated slightly outward and finally, by circumducting externally, it is swept across the abdomen and brought down in a straight position beside the other limb.

Allis (in Wharton and Curtis) recommends the following steps: The surgeon kneeling beside the recumbent patient, in the case of the right hip, should grasp the ankle with the right hand and place the bent elbow of the left arm in the popliteal space; then he should turn the leg outward, by means of the ankle, and should lift it upward with the left arm; finally, he

should turn the leg inward and should bring the femur down into the position of extension.

Hamilton gives the following: "The patient being laid upon his back upon a mattress, the surgeon, assuming that it is a dislocation upon the dorsum ilii, should seize the foot with one hand, and the other he should place under the knee; then flexing the leg upon the thigh, the knee is to be lifted carefully toward the face of the patient until it meets with some resistance; it must then be moved outward and slightly rotated in the same direction until resistance again is encountered, when it must be gradually brought downward again to the bed."

Fig. 1751.—Manipulation Method for Reduction of Dislocation of the Thigh, First Stage, Showing Flexion of Knee and Hip to a Right Angle. (Helferich.)

I also quote the following from Stonham:[11] "In all forms of dislocations the patient is most conveniently placed upon a hard mattress on the floor, the surgeon thus having full command of the limb. He must be fully anesthetized. In the dorsal dislocations the surgeon, flexing the knee to a right angle, grasps the leg above the ankle, and just below the knee. The thigh is now flexed upon the abdomen to a right angle, and the patient is slightly raised from the mattress so that his body becomes a counter-extending force; if this be insufficient his pelvis may be fixed by an assistant, or the surgeon may exert pressure on the anterior superior iliac spine with his unbooted foot. The femur is now abducted and

Fig. 1752.—Extension. Sir Astley Cooper's Method.

rotated out, and thus the head is brought nearer the acetabulum; finally the limb is extended and the head slips into the socket. The formula for reduction is 'lift up, bend up, roll out, and extend.' If any difficulty is experienced it will most likely be due, not only in the dorsal, but in all regular dislocations, to the smallness of the aperture in the capsule; this is to be made larger, without fear of inflicting much additional damage, by circumduction in the direction opposite to that which the head of the bone must subsequently travel. In the other cases adduction and inversion may be slightly increased in order to disengage the head of the bone."

"In the everted dorsal dislocation it may be converted into the ordinary dorsal by flexion, adduction, and inward rotation of the limb," says Mr. Stonham; and according to him "Bigelow recommends that the head should be disengaged by circumduction of the extended limb inward, coupled with eversion to free it from the edge of the pelvis in the supraspinous form." "The anterior oblique may be converted into the ordinary dorsal form by inward circumduction and internal rotation."

Charles A. Sturrock[12] has advised the following method of reducing dislocations of the hip: "The patient is laid upon the back and anesthetized. The surgeon kneels upon the left knee and at the left side of the patient in a dislocation of the left hip. The patient's thigh is then carefully flexed to a right angle, and while this is being done the leg is also flexed to a right angle and laid with the most prominent part of the calf on the right knee of the surgeon. The ankle is then firmly grasped with the left hand, and the condyles of the femur with the right. The thigh is abducted for thyroid dislocations, adducted for dorsal and pubic, and rotated inward for all, by drawing the foot away from the middle line and keeping the knee steady. Traction is now made by steadily depressing the ankle, the surgeon using his knee for a fulcrum; the patient's leg makes a most powerful lever, and the pelvis can be easily raised from the ground if necessary, the body acting as a counteraction; finally the thigh is rotated out, and while this is being done the head of the femur slips into place."

These methods all act in the manner suggested by Prof. Nathan Smith, and the points brought out in regard to the iliofemoral or Y-ligament, so philosophically considered by Dr. Bigelow, are the important factors in the pathology and reduction of this dislocation—the Y-ligament being a reinforcement of the capsular ligament. The method of Allis and that of Sturrock give the surgeon greater power in making extension and counterextension during the manipulation. Sir Astley Cooper's method of employing the compound pulleys, and other devices, mechanical in their character, for extension and counterextension, are now abandoned as being very liable to produce injury (through the employment of excessive force) in all recent dislocations; and, with the means suggested above, they are needed only as adjuvants to manipulation, if at all. Manipulation is to some extent impeded by mechanical devices, for they interfere with the freedom of movement; I never resort to them unless I am absolutely forced to do so through the failure of other means, and then I rely upon them only as aids to the proper movements of the limb. I am convinced that I can accomplish more—while at the same time incurring a smaller risk—by a careful study of the mechanism of the dislocation and by employing dexterity, than by resorting to violent force.

Dr. Lewis A. Stimson[7] has had success with the following method. "In dorsal dislocations of the hip the patient is placed prone upon a table, with thighs extending beyond its end. The uninjured thigh is held horizontal to prevent tilting of the pelvis. With the injured thigh vertical, and leg at a right angle to it, the surgeon grasps the ankle and gently moves it from side to side, perhaps making gentle pressure downward at the knee. If relaxation is slow to appear a sand-bag weighing five or ten pounds may be placed in the popliteal space to produce more traction. This simple procedure has succeeded in reducing the dislocation in more than four-fifths of the cases, and often without anesthesia. In the two cases failing by this method, reduction was accomplished by traction in a line midway between right-angled flexion and full extension. In these cases the bone had probably left the socket at a higher point." (See Fig. 1753.)

When reduction has been accomplished the limb

may be kept in position by sand bags or by the use of a long fixed splint, the patient being kept in bed for about two weeks; at the end of this time passive motion may be gradually essayed, and the patient

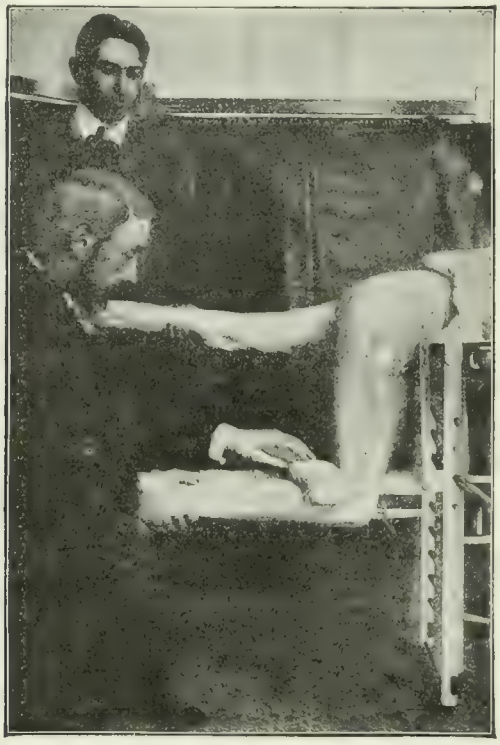

Fig. 1753.—Stimson's Method of Reducing Dislocations of the Hip.

Fig. 1754.—Luxation in Ischiatic Notch. (From a Photograph.)

allowed to get about on crutches, but he should not actually use the limb until after the expiration of a month. At the end of five or six weeks all support may be dispensed with.

As before stated, in connection with other dislocations, it is not time alone that determines when a dislocation at the hip-joint becomes ancient. However, if two months have elapsed, forcible attempts are likely to be dangerous and failure to effect a reduction is common, the danger becoming greater and

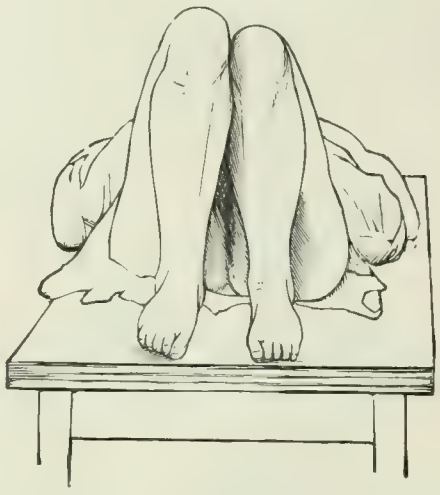

Fig. 1755.—Luxation in the Ischiatic Notch. The same case as that shown in Fig. 1754.

the failure more certain with the advance of time. Nevertheless, attempts are justifiable and may prove successful and safe in one individual at the end of a certain period, while the obverse is the case in another individual after the lapse of the same or even a shorter period of time.

*Dislocation into the Sciatic Notch.*—In this dislocation the head of the bone passes backward and a little upward, and rests upon the ischium at the margin (generally) of the sciatic notch, below the tendon of the obturator internus muscle. The causes are the same as those given for the previous dislocation.

Symptoms are the same as those of dislocation upon the dorsum of the ilium, but they are not so marked. There are flattening and broadening of the hip; ascent of the great trochanter above Nélaton's line; flexion, inward rotation, adduction, and shortening to the extent of an inch. The axis of the dislocated limb would pass through the knee of the sound side, lower down than in the dorsum ilii dislocation. If the patient be placed recumbent and the thighs brought to a right angle with the body, shortening on the affected side is materially increased, and if the dislocated thigh is extended, the back arches as in hip disease.

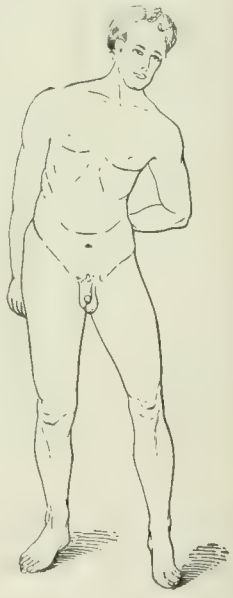

Fig. 1756.—Thyroid Dislocations.

Reduction is effected in the same way as in dislocation upon the dorsum of the ilium.

*Dislocations into the thyroid foramen* are caused by violent abduction in falls or in stepping from a moving car. As stated, nearly all hip dislocations

are primarily in the obturator or thyroid foramen, but usually mount up in some other position as a result of muscular action.

Symptoms.—Flattening of the hip; the head of the bone is felt in its new position and is missed in the

Fig. 1757.—Reduction of Thyroid Dislocation by Manipulation. (Bigelow.)

socket; rigidity; passive motion is possible only in the direction of the deformity; hollow over the great trochanter, which is below Nélaton's line; and the gluteal crease is lower than on the uninjured side. There is lengthening to the extent of one or two

Fig. 1758.—Mechanism of Dislocation into Thyroid Foramen, Showing the Y-ligament Suspending the Trochanter. (Bigelow.)

inches; abduction and eversion of the limb. The body is bent forward by the traction upon the psoas and iliacus muscles and is also leaning to the dislocated side. The knees cannot be pushed together without great pain and the abductor muscles are rigid.

Treatment.—Effect reduction by manipulation; if this fails then by extension. To reduce by manipulation, flex the leg on the thigh and the thigh on the pelvis, and then perform, in the following order, abduction, internal circumduction, and extension. This makes the head of the bone retrace its steps over the same route it took on emerging. Allis advises to fix the pelvis to the floor; pull the head of the femur outward and above the socket; fix the head; push the knee toward the sound knee, and extend the femur.

Fig. 1759.—Pubic Dislocation.

If extension is made, make traction in the axis of the limb by means of muslin fastened around the thigh by a clove-hitch. Do not use pulleys; incise rather than use them.

Falling upon the foot or knee, when the thigh is drawn backward from a perpendicular, or violent twists of the limb, may dislocate the head of the femur *forward and upward on the pubes*, causing it to lodge internally to the pubic eminence. The limb will be shortened and abducted, the thigh flexed, and the foot everted; the trochanter will be less prominent, and the head of the bone will be apparent in front of the pubes. This dislocation is liable to be confounded with fracture of the neck of the femur. In pubic dislocation there will be absence of crepitus, immobility, abduction and flexion of the thigh; whereas in fracture there will be crepitus, increased mobility, and the thigh will be neither flexed nor abducted.

*Treatment.*—For the reduction of this dislocation the leg must be flexed upon the thigh, and the thigh carried forcibly up to the abdomen until it rests in contact with it, thus relaxing the Y-ligament and lifting the head of the bone off the pubis. As the next step the thigh must be rotated inward, and then, during adduction, the limb must be brought down toward and parallel with its fellow. If the luxation is suprapubic, in carrying the limb from its abnormal position of abduction to that of adduction it is not necessary to carry it so far across the body as in thyroid dislocation.

The suggestions as to after-treatment and in regard to ancient luxations, which were made in connection with the subject of dorsal dislocations, are equally appropriate for this as well as the other forms of dislocation of the thigh.

Fig. 1760.—Outward Dislocation of the Patella.

Dislocations of the patella are somewhat rare, and are due to sudden muscular contraction, to forcible torsion of the joint, or to the action of a force operating against one or the other side, the disloca-

tions then being lateral. Separation of the tubercle of the tibia, or of the apex of the patella, may permit the bone to be displaced upward—a variety of displacement which partakes more of the nature of a fracture and requires the same treatment.

Fig. 1761.—Outward Dislocation of the Patella.

In outward dislocation of the bone, which is the more frequent form, the breadth of the knee is increased, the internal condyle is prominent, the limb a little flexed, the joint fixed, and the borders of the bone may be felt as it lies in an anteroposterior direction toward the outer side of the joint. Reduction is usually easy, the bone sometimes slipping back unaided. If interference is needed, it will be found sufficient to flex the thigh to a right angle—the patient lying on the back, with the leg extended to relax the quadriceps tendon—and then to exert lateral pressure upon the bone by depressing the edge of same farthest away from the center of the knee and pushing it in place.

In some cases the dislocation may consist in a partial or even complete rotation of the bone on its perpendicular axis. Under these circumstances the limb will be found in a position of complete extension, and there will be no difficulty in making out the position of the bone on account of its nearness to the surface of the skin. It may lie to either side or in front of its proper site. Rotary dislocations, as they are termed, require forced flexion of the thigh upon the abdomen, the leg being in an extended position; and if manipulation, on the part of the surgeon alone, fails to restore the patella to its natural position, the addition of alternate flexion and extension, to be carried out by an assistant, will aid the surgeon in his efforts to manipulate the bone back into its place with his fingers. After the patella has been reduced, the limb should be fixed by means of a posterior splint or by a plaster-of-Paris dressing for at least three or four weeks. For a week or ten days after the occurrence of the dislocation cold applications, in the form of an ice-bag, cold cloths, etc., should be made to the knee, or lead and opium wash should be applied, and then, after the temporary dressings are removed, a stout knee-cap should be worn for some time, the patient being cautioned as to the liability of a recurrence of the dislocation.

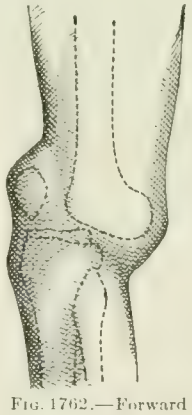

Fig. 1762.—Forward Dislocation of the Leg. (Helferich.)

The Knee.—This joint may be dislocated forward, backward, or laterally. *Forward dislocation* may be complete or incomplete, and is the result of over-extension of the knee. In complete dislocation the leg will be shortened to an extent of from one to three inches, and may be extended or slightly flexed. The head of the tibia will be found to project in front, with the patella resting on it or in the depression above it, while the lower end of the femur will project backward.

For the reduction of this dislocation anesthesia may be required. Extension having been applied to the leg and counterextension to the thigh, the patient lying on the back, the surgeon gradually flexes the leg over his arm and at the same time makes pressure forward in the popliteal space. For a period of a week or ten days, after the dislocation has been reduced, the limb should be placed on a well-padded posterior splint, and local applications of cold or of anodynes should be resorted to for the purpose of subduing inflammation. Then, for about three weeks, a plaster-of-Paris dressing should be employed, after which the patient should be allowed to use the limb cautiously, the joint being guarded or protected by some form of splint or brace.

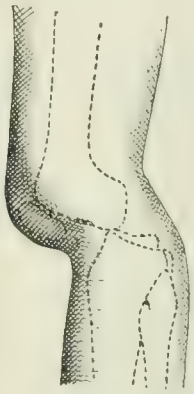

Fig. 1763.—Backward Dislocation of the Leg. (Helferich.)

In *backward dislocation*, which may be complete or incomplete, and is due to force applied to the front of the leg or to the back of the thigh, the patella is generally displaced in an outward direction, and the leg is in a condition of extreme extension, shortened, and it may be bent forward. The femur will be felt anteriorly, and the head of the tibia posteriorly. Extension and counterextension with manipulation, at the hands of the surgeon, should suffice for reduction; the after-treatment being the same as in the former variety.

Lateral dislocations are generally incomplete, and if complete they are very apt to be compound. The patella is displaced and there is a laceration of the lateral as well as the crucial ligaments. There is no shortening of the limb, which is generally extended. Reduction is usually accomplished without difficulty by extension and counterextension, combined with manipulation of the bone in the proper direction. The after-treatment is the same as in the other forms of dislocation of the knee.

Fig. 1764.—Incomplete Outward Dislocation of Tibia.

In order to overcome the contraction of the powerful muscles of the limb, anesthesia may be required in all dislocations of the knee. Extension and counterextension by means of mechanical devices, as well as forced flexion and slight rotary movements of the tibia, may also be needed; yet we must bear well in mind at all times, in carrying out these procedures, the possible danger of seriously injuring the popliteal vessels. As a matter of fact this very injury may have already occurred at the time of the accident.

In rare instances the head of the tibia may be twisted outward or inward, and when the attempt is made to reduce the dislocation it will be found necessary to rotate in the opposite direction while extension and counterextension are made.

Compound dislocations of the knee require the most

thorough attention to aseptic details and possibly also to drainage. After reduction has been effected it will be necessary to apply an immovable straight dressing. In some cases it may even be necessary to resort to partial or complete excision of the joint. If ankylosis develops, the limb may be permitted to assume a position of slight flexion.

As a result of a sudden twisting of the leg, when semiflexed, the semilunar cartilages may be forced from their natural position. Twisting the leg outward will displace the internal cartilage, while torsion inward displaces the external. The first indication of the fact that this has occurred will be a sharp, sickening pain in the knee, immediately following, in some cases, a perceptible snap. The knee remains fixed in its semiflexed condition, and the cartilage may present an elevation on the outer or inner aspect of the knee—except in those cases in which the anterior edge is torn away and undergoes displacement inward toward the middle line, when there will be a slight depression opposite it. Recurrence is common. Reduction is effected by increasing the flexion and rotating the leg to the side of the displaced cartilage. If this does not succeed, flexion may alternate with slight extension and rotation. Synovitis, mild or severe, will follow, and rest of the joint, with local measures to combat inflammation, must be resorted to. If a well-made knee-cap fails to secure the retention of the cartilage in its proper place, and if in consequence much inconvenience results, the cartilage must be removed under strict asepsis. Attempts at fixing it by other operative procedures will prove only annoying and futile.

*The upper end of the fibula* may be displaced forward or backward, the anterior and posterior tibiofibular ligaments being torn. This displacement is indicated by mobility of the head of the bone, and by the fact that the affected limb is unable to bear the weight of the body. By flexing the leg upon the thigh and thus relaxing the biceps, the head of the bone may be pushed into place. A moulded leather, guttapercha, or binder's-board splint with a compress placed over the head of the bone, or a plaster-of-Paris dressing, should be applied; and in some cases it will be found necessary for the patient to wear such a dressing permanently.

*The lower end of the fibula* may be torn from its attachments and the foot displaced backward. By extension of the foot and manipulation the bone may be replaced, and maintained in its proper place by a fixed dressing of plaster of Paris or other material.

Dislocation of the ankle, unaccompanied by fracture, is extremely rare, and is caused by a violent movement of the limb when the foot is fixed. It may occur in a direction forward, backward, laterally, or upward.

In *forward dislocation* the foot will be lengthened and the heel shortened, while the tendo Achillis, resting against the tibia, will have lost its prominence. (Fig. 1765.) For the reduction of this dislocation the leg should be flexed upon the thigh, in order to relax the soleus and the gastrocnemius; then extension should be applied to the foot and counterextension to the knee. In some cases an anesthetic may be needed, and possibly also subcutaneous section of the tendo Achillis. The foot should be kept at rest, with temporary splints, until the swelling has subsided; after which a plaster-of-Paris dressing may be applied.

In *backward dislocation* the foot, while in an extended position, may, through the action of some violent force, be drawn backward, until the tibia rests upon the neck or head of the astragalus, or upon the scaphoid or even as far forward as the cuneiform bones. (Fig. 1766.) The foot will then appear shortened from the ankle forward, and the heel will be extended and elevated. At the same time the tendo Achillis will be unusually prominent and the toes will point downward. For the reduction of this dislocation counterextension must be made from above the knee by an assistant, while the surgeon makes traction upon the foot and extends it with one hand, and with the other pushes the lower end of the tibia back. The after-treatment is the same as that advised for forward displacements. Section of the tendo Achillis facilitates the reduction and lessens the tendency to subsequent displacement.

Fig. 1765.—Forward Dislocation of the Foot, the Front Part Appearing to be Lengthened While the Heel Does not Project to the Normal Extent.

In *outward dislocation* at the ankle we have marked eversion of the foot and prominence of the internal malleolus, the foot resting on its outer border. The deformity is the same as that of Pott's fracture, with which it is usually associated.

In *inward dislocation*, which occurs more rarely, the foot is inverted and the external malleolus is more prominent. In reducing it the surgeon must make extension from the foot and counterextension from the leg, in combination with such manipulations as may be found necessary.

*Dislocation upward of the ankle-joint*, or Nélaton's dislocation, is a very rare injury. The astragalus is wedged between the widely separated tibia and

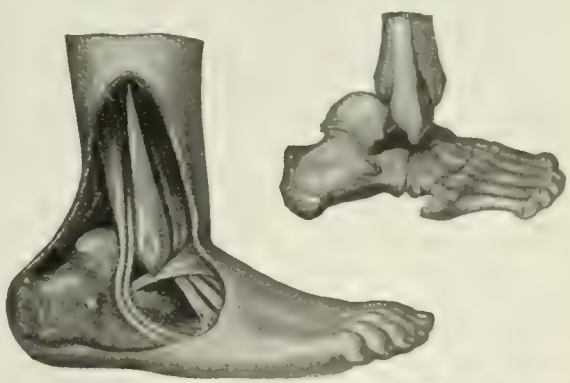

Fig. 1766.—Backward Displacement of the Foot, the Peroneal Tendons Being Placed Between the Astragalus and the Malleolus, and the Foot Apparently Shortened While the Heel Projects abnormally.

fibula, and is usually complicated with a fracture. The cause is a fall upon the foot from a great height.

Symptoms.—The dislocation is indicated by the widening of the ankle and by flattening of the foot. The malleoli are nearly on a level with the plantar surface of the foot, and there is great rigidity.

Treatment.—Give ether and reduce by powerful extension and counterextension. Immobilize afterward as you would for a fracture.

If fracture accompanies the dislocation, which is the rule, we shall have crepitus, immediate recurrence after reduction, and the other signs of fracture accompanying the deformity of the peculiar dislocation. The after-treatment in all cases is similar to that needed for fracture. Temporary dressings are to be applied until all swelling and inflammation have subsided, and then the plaster-of-Paris or other dressing of a permanent character may be used.

In compound dislocations the following measures are of importance; thorough asepsis, free drainage,

Fig. 1767.—Backward Displacement of the Foot, the Peroneal Tendons Being Placed between the Astragalus and the Malleolus, and the foot apparently Shortened While the Heel Projects abnormally.

and excision, partial or complete; and if there is much suppuration, which must be carefully watched for, irrigation will be required.

*Tarsus.—The astragalus* may be dislocated forward, backward, or laterally, or it may be rotated on its axis.

In *forward dislocation*, which may be complete or incomplete, the foot is generally inverted with the external malleolus prominent, and with an irregularly shaped prominence in front of the ankle. By flexing the leg upon the thigh and then resorting to extension and counterextension from the foot and leg, the surgeon may be able to push the bone back into place. In some cases it may be necessary to divide the tendo Achillis or to resect the bone.

In *posterior displacement* the foot is shortened, the heel is prominent, and the tendo Achillis is stretched over the projecting end of the bone. Reduction may be accomplished by extension and counterextension from the foot and leg. The latter, however, must first be flexed on the thigh, and in his manipulations the surgeon must push the bones of the leg backward and pull the foot forward. Anesthesia may be required, and even with this assistance all efforts may prove ineffectual. In some of these cases, however, the foot may prove to be comparatively useful despite the deformity; in others it will be found necessary to resort to excision.

*Lateral dislocations* are, as a rule, associated with fracture of one or the other malleolus, and efforts at reduction, similar to those already cited, may be tried.

*Dislocation by rotation* is extremely rare. The astragalus, which occupies a position between the malleoli, may be turned vertically or transversely. There will be fixation of the ankle with change in its shape. Extension and counterextension, with manipulation and even section of the tendo Achillis, may fail to restore the bone to its place, and excision may then be required.

The after-treatment of these luxations should be the same as that advised in the paragraph relating to the after-treatment of compound dislocations.

In *subastragaloid dislocations* we have the astragalus separated from its articulations with the scaphoid and os calcis, while yet retaining its connections with the bones of the leg. These dislocations result from the same causes as those which produce true dislocations of the astragalus; they may also occur in the same directions as the latter. As regards the diagnosis and treatment nothing additional needs to be said. If the injury is compound, amputation may be essential, either by Syme's or by the subastragaloid plan.

*The os calcis* becomes separated from the astragalus above and the cuboid in front only in rare cases. The heel will be distorted, and there will be inability to abduct or adduct the foot. This dislocation, which is easily recognized, will require anesthesia and manipulation and pressure for its replacement.

*Dislocation of the scaphoid* is also a rare accident and will be recognized by its projection on the anterior surface of the foot. By making traction on the metatarsus the bone may be pressed back into place.

*The cuboid* may be dislocated in connection with the other tarsal bones, but an independent luxation of this bone has not been reported.

*The cuneiform bones* may be dislocated separately or as a whole. By exerting force upon the metatarsal bones in an outward direction, they may be pushed into place. All these injuries require a temporary fixed dressing until swelling subsides, and then the foot may be put up in a permanent fixed dressing, which should be worn for four or five weeks.

*Foot.—Dislocation of the metatarsals and phalanges of the foot* occurs much more rarely than does dislocation of the corresponding bones of the hand. The diagnosis is easy, and reduction is to be accomplished by the ordinary measures of manipulation and extension, though the task is more difficult in the case of the foot than in that of the hand. After the dislocation has been reduced a fixed dressing of plaster-of-Paris or a moulded splint of leather, guttapercha, or binder's board, should be worn for several weeks, to secure apposition and rest.

Duncan Eve.

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**Dislocations, Congenital.**—Congenital misplacements at other joints are quite insignificant in number when compared with that at the hip, and in only two situations is the disability of sufficient importance to require especial consideration. These are the shoulder and the knee.

The Hip.—Congenital dislocation of the hip-joint is by far the most common and the most important of this class of disability. It is much more common in females than in males, as is illustrated by the following statistics: Of 3,202 cases collected from various sources, 2,711 (84.6 per cent.) were in females and 591 (15.4 per cent.) were in males. Of 2,163 cases, 598 (27.6 per cent.) were on the right side, 821 (37.9 per cent.) were on the left side, and 744 (34.4 per cent.) were bilateral.

The dislocation at the time when the patients are brought for treatment is usually posterior, upon the dorsum of the ilium. In other instances it is anterior, the head of the bone lying below the anterior superior spine. Occasionally the displacement appears to be a subluxation due to laxity of the capsule; in such cases it may be directly upward, supracotyloid. This form is more often seen in infancy, and it represents possibly the primary displacement of a much larger proportion of the total number, which changes to the ordinary form under functional use.

Fig. 1768.—Subluxation of the Head of the Femur.

*Pathology.*—The degree of abnormality of the joint and of the surrounding parts varies with the age of the patient and with the strain and friction to which the displaced parts have been subjected. At birth it may be assumed that the head of the bone lies in close proximity to a fairly normal if somewhat rudimentary acetabulum. At a later time, when the joint is exposed at operation at the age of four years or more, the acetabulum may be partly filled with fat and fibrous tissue. As a rule, however, a well-marked ridge indicating its posterior and upper margin can be made out and in many instances it appears to be of fair size and depth, but usually smaller and shallower than normal, and in older subjects often contracted at its upper margin to a somewhat triangular form.

The capsule is elongated to accommodate the upward dislocation of the femur. It is hypertrophied, and it is often of a shape like an hourglass; the upper part contains the head of the bone; the anterior wall is drawn tightly across the acetabulum, forming at its upper border a narrow, slit-like communication, through which the ligamentum teres passes, if it be present. The interior of the capsule is in part lined with synovial membrane, and it often contains more synovial fluid than is found in the normal joint.

The ligamentum teres, although probably present at birth in a large proportion of the cases, becomes attenuated and ribbon-like with the increasing elongation of the capsule, and after the age of five years it is usually absent or very rudimentary.

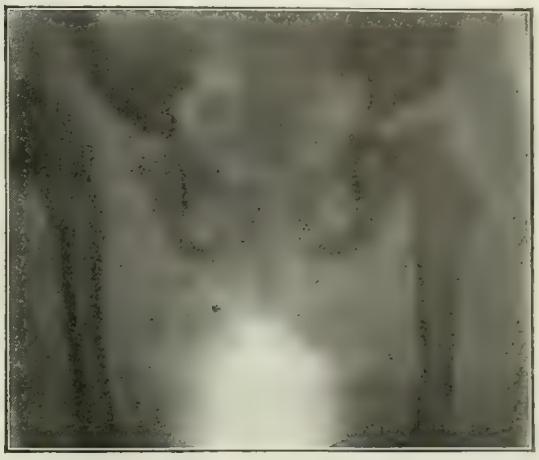

Fig. 1769.—Congenital Dislocation of the Hip of the Anterior Variety, with Anteversion of the Neck.

A shallow depression formed in part by the direct pressure of the head of the bone through the adherent capsule, and in part the result of irritation of the periosteum is usually found upon the ilium, but as it is not often of sufficient depth to assure a secure support for the head of the femur its upper margin gradually recedes or two distinct depressions may be formed one above the other. The upper extremity of the femur is usually somewhat atrophied. The neck is often shorter than normal, its angle may be lessened and in many instances its forward inclination is increased (anteversion). The head of the bone may be nearly normal, although usually it is flattened on its inner and under surface, or it may be somewhat conical, or again compressed from side to side to an almond shape or otherwise distorted.

There are also secondary changes in the bones of the pelvis. In unilateral dislocation the pelvis is usually somewhat atrophied on the affected side, and a lateral inclination of the spine may be present. The final changes in the pelvis caused by the bilateral dislocation are more important; its inclination is increased, the lumbar lordosis is exaggerated, the sacrum is forced forward and downward so that the antero-posterior diameter is lessened; the tuberosities of the ischia are everted and the transverse diameter of the pelvic outlet is increased.

The long muscles of the thigh are shortened, while those attached about the trochanter are changed in direction and are usually lengthened. There is also a slight general muscular atrophy most noticeable in the gluteal group. The changes become more marked with increasing age, and in some of the adult specimens but little resemblance to the normal parts remains.

As a rule, congenital dislocation of the hip is not

accompanied by defective development or deformity elsewhere; although cases are sometimes seen in which a general laxity of ligaments is present or in which the dislocation may be one of a series of deformities and malformations.

*Etiology.*—Nothing positive is known of the etiology of the dislocation. In a small proportion of the unilateral cases it may be due to violence at birth, but the fact that nearly eighty-five per cent. of the patients are females indicates that the primary cause can be neither injury nor disease.

Hereditary influence can be established in a few instances and the displacement may be present in more than one of the same family. The writer has examined three female children, in a family of nine, in each of whom there was dislocation of the left hip, the order being the third, eighth, and ninth child; also twins, one with single and the other with double dislocation. In but two instances in a large number of observations, was it certain that congenital displacement was present in the mothers of the patients.

Of the various theories that have been advanced to account for the condition, the most reasonable seems to be defective development either of the entire acetabulum or of its posterior margin. This defective development may be primary or it may be secondary to a fixed position of the limb in adduction and flexion.

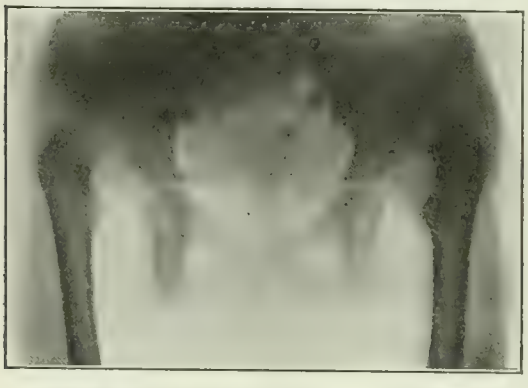

Fig. 1770.—Bilateral Congenital Dislocation of the Hip.

Heusner accounts for the greater liability of females to the dislocation by disproportionate laxity of the capsule which he thinks is characteristic of the sex. It is probable that the dislocation in many instances is at birth a subluxation only that becomes complete through muscular action and by the use of the limb in standing and walking.

*Symptoms.*—The displacement does not as a rule attract attention until the child begins to walk; although in some cases the mother may have noticed a peculiar breadth of pelvis, or a "lump" on the buttock, or a "snapping" about the hip-joint, or a peculiar attitude of the limb before this time.

*Unilateral Dislocation.*—If the displacement is of one side, a limp is immediately apparent, and this becomes more noticeable as the child grows older. The limp is characteristic of the affection, for the limb is not only shorter than its fellow but owing to the elasticity of the capsule it becomes still shorter when weight falls upon it. Thus in walking there is a peculiar lunge of the body toward the affected side. In most instances the dislocation is upon the dorsum of the ilium, the head of the femur being displaced upward and backward. In compensation the pelvis is tilted toward the short leg and its inclination is increased. It is also rotated forward so that the anterior superior spine lies on a lower plane, and in advance of that of the opposite side.

When the child begins to walk the shortening of the limb is from one-half to three-quarters of an inch. In adolescence it is from one and a half to three inches or even more, the shortening increasing as the capsule elongates under pressure.

Other signs are the flattening of the buttock and the elevated and prominent trochanter which may be seen or felt as an abnormal lateral projection, on a level with the anterior superior spine, which is, as has been stated, somewhat tilted downward.

In early life the attitude of the limb is practically normal and motion is unrestricted. There is, in fact, an abnormal mobility that may be demonstrated by alternate traction and upward pressure on the limb. As the femur becomes larger and the upward displacement increases, the mobility is restricted; the range of abduction in particular is much diminished and not infrequently the limb becomes permanently adducted and flexed, thus adding the apparent shortening of adduction to that caused by the dislocation.

Fig. 1771.—Unilateral Dislocation Showing the Inclination of the Body Toward the Shorter Limb.

*Bilateral Dislocation.*—When the dislocation is bilateral the shortening of the limbs is, as a rule, equal or nearly so, and as both femora are usually displaced backward the pelvis is tilted forward. In compensation the hollow of the back is increased, the abdomen protrudes, the buttocks are flattened, the pelvis appears to be abnormally wide, and the thighs are separated by a considerable interval. The limp characteristic of the single displacement is replaced by an exaggerated waddle, a "sailor gait."

In early childhood there may be no symptoms other than the physical signs that have been described, but as the child becomes more active it usually complains of discomfort after exertion. It is easily fatigued and at times it may suffer actual pain. These symptoms are of course more marked in the double than in the single displacement, because in the latter case the normal joint is capable of bearing more than its share of the strain. The symptoms often increase during adolescence, but they may become less troublesome in adult life if a permanent resting-place on the pelvis is secured. This security is often assured, however, by a corresponding limitation of the range of motion. The physical signs of course persist and the individual is, as compared with the normal standard, more or less disabled and deformed. Fortunately the great majority of the patients are females, and because of the less laborious occupations and the distinctive dress, the disability and its effects are less serious

than if the displacement were more equally divided between the sexes.

The symptoms of the anterior dislocation in which the head of the bone lies beneath the anterior superior spine, are less marked because the relation of the pelvis to the femur is nearly normal, so that secondary deformity is slight. The shortening is less and the

Fig. 1772.—Bilateral Dislocation Showing the Relative Shortening of the Lower Limbs and the Apparent Broadening of the Pelvis.

resistance of the tissues attached to the anterior superior spine is sufficient to assure a more secure support than in the ordinary form, so that the limp is less noticeable. In bilateral anterior dislocation there is a swaying backward of the body, but the exaggerated lordosis is absent.

*Diagnosis.*—The diagnosis offers no difficulty. The history of the limp, at once apparent when the child began to walk, yet not accompanied by pain or preceded by injury or disease, is in itself sufficiently distinctive. If the displacement is of one side measurement demonstrates the shortening as compared with the other limb, a shortening that is explained by the prominence and the elevation of the trochanter above Nélaton's line. Traction and upward pressure on the limb will demonstrate the abnormal mobility of the displaced head; and finally if the thigh be flexed and adducted to its extreme limit, the neck and head of the femur can be easily distinguished moving under the gluteal muscles when the limb is rotated. Thus it may be differentiated from depression of the neck of the femur (coxa vara), in which, although the trochanter is elevated, the neck and head of the bone cannot be felt, and in which the abnormal mobility, characteristic of the dislocation, is absent. Again, coxa vara is almost never a congenital affection, therefore the history itself would practically exclude it.

Upward displacement of the femur not infrequently follows infectious epiphysitis in infancy or early childhood. In such cases a part of the upper extremity of the bone is usually destroyed so that the head cannot be distinguished on palpation. Although the other physical signs are similar to those of the congenital displacement, the scars about the joint show the evidence of former disease and the history is almost always available for diagnosis, so that as a rule such disabilities as well as traumatic dislocations or other results of injury or disease are readily excluded.

Certain of the minor symptoms of congenital dislocation may be simulated by other affections, but these may be excluded readily by the physical examination.

In doubtful cases a Roentgen picture will demonstrate the character of the disability.

*Treatment.*—The principles of the treatment are simple, since it is evident that the only cure of a dislocation must be replacement of the displaced part. The application of these principles may be difficult, however, because of the congenital or acquired abnormalities that may interfere with reduction or with the functional ability of the limb after treatment.

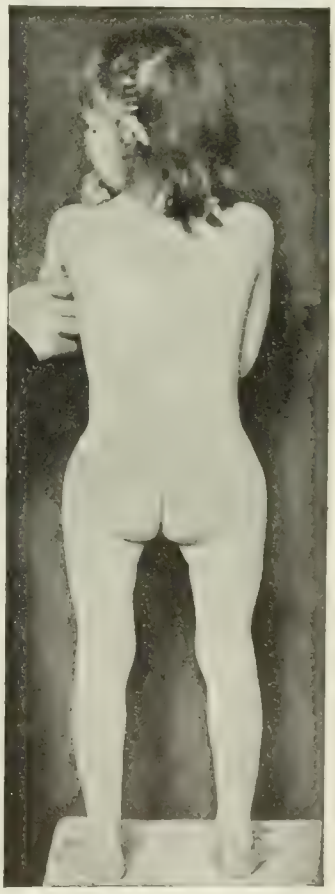

Fig. 1773.—Bilateral Dislocation Showing the Separation of the Thighs

The operation of choice is forcible reduction without cutting, introduced by Lorenz, although a similar though less effective method was first advocated by Paci.

The Lorenz treatment is based upon the theory that if parts about the joint can be sufficiently stretched to allow the head of the bone to be brought into direct contact with the rudimentary acetabulum, and if it can be held for a sufficient time in this position, the weight of the body in walking, constantly forcing the bone against the substance that partly fills it, will gradually enlarge its capacity in adaptation to its restored function. Thus he calls it the "functional weighting" method, and this is its essential and vital distinction from the method of Paci.

The steps of the operation are: 1. Elongation of the Limb. The trochanter must be brought down to the level of Nélaton's line or lower. This may be accomplished by preliminary traction in bed with heavy weights as in the treatment of older patients or

Fig. 1774.—Bilateral Dislocation Showing Habitual Flexion of the Thighs and the Increased Inclination of the Pelvis.

by direct manual force at the time of operation, but ordinarily by natural leverage. The patient is placed upon the table with a folded sheet beneath the buttocks. The thighs are then flexed to right angles with the trunk. The assistant fixes the pelvis and limb on the sound side and the operator then gradually and forcibly abducts the thigh, stretching and often rupturing the adductors, until the limb is brought down nearly to the plane of the table. The contractions on the posterior aspect are overcome by flexing the extended limb on the body with increasing force until the toes touch the face. The patient is then turned upon the side and the limb is hyperextended in the same manner. These manipulations overcome the resistance of the muscles, stretch the contracted capsule, and enlarge the entrance to the acetabulum. If now the trochanter can by traction be brought nearly down to its proper relation to Nélaton's line, reduction is attempted. The patient is placed in the first position with the thighs flexed to a right angle on the trunk, the pelvis being firmly fixed by the assistant. The thigh is then abducted over a padded wedge of wood placed between the trochanter and the pelvis and during this movement, in successful cases, the head springs upward over the posterior rim of the acetabulum with a distinct shock, the tension on the shortened muscles causing fixed flexion of the leg on the thigh. The capacity of the point is then further increased by rotating the limb from side to side and further exaggerating the abduction in order to force the head well forward. The stability of the new articulation may then be tested by successively reducing the abduction and the flexion to decide as to the degree of distortion required to assure stability.

In most instances the abduction may be lessened in marked degree, indicating a prominent dorsal rim of the acetabulum but if the limb is drawn downward the head snaps over its superior margin. The next step is to fix the limb in a position in which reluxation is impossible, the typical position being that already described of overabduction from the original attitude of right-angled flexion of the thigh on the body. This position Lorenz describes as one of extreme abduction, extension, and outward rotation, a description which is somewhat less intelligible to most readers than that adopted. In this attitude, if the reduction is successful, the head of the bone should lie directly under the femoral artery, where it often forms a distinct prominence beneath Poupart's ligament. A short plaster spica bandage is then applied reaching to the knee where it is cut out sufficiently behind to allow flexion of the leg on the thigh. The body part of the spica may be of the usual form or made after the Lorenz method by figure-of-eight turns about the pelvis so that the iliac crests are firmly fixed. This pelvic portion, which is made at least one-half inch in thickness, is then cut out as in the illustration so that it does not restrict greatly the movements of the trunk. If greater fixation is required, as when it is difficult to hold the head of the femur in the acetabulum, the support may be extended below the knee, to hold the leg at a right angle to the thigh, the body portion being made longer like a plaster jacket to balance the greater leverage. In cases treated at the proper time, in infancy and early childhood, forcible stretching by leverage is unnecessary, the head being readily reduced by abduction together with upward pressure of the femur below the trochanter. In some cases in which the reduction is made easily and the joint is evidently fairly secure, the limb may be fixed in an intermediate position.

In the ordinary class of cases or up to the age of about four years, the reduction in the manner described is not especially difficult. In older subjects, as has been mentioned, preliminary traction in bed until the muscular shortening is in great part overcome is indicated. In certain resistant cases of this class tenotomy of the hamstrings, of the adductors, and of the muscles attached to the anterior superior spine may be required. If reduction is especially difficult, the limb should be fixed by the plaster support in the typical attitude and reposition again attempted in a week or two when often it may be easily accomplished.

Formerly the attempts at reduction were prolonged and great force was used. In consequence a number of accidents have been recorded; for example, fracture of the neck of the femur, paralysis due to forcible stretching of the nerves, necrosis of soft parts, and

Fig. 1775.—Reduction of Dislocation of the Right Hip. First step. The operator overcomes the resistance offered by the adductors by forcible massage. (Whitman's Orthopedic Surgery, Lea & Febiger.)

several deaths from shock. As a rule, however, in the cases operated on within a reasonable limit of age, surprisingly little discomfort is experienced. There is usually some discoloration with swelling of the adductor region and discomfort lasting for several days, after which no complaint is made by the patient, who soon attempts to walk. If the limb is fixed in the ordinary position, that is drawn up to about a right angle with the trunk, a shoe with a cork sole two or three inches in height should be worn on the operated side. This first support should be retained for several months; in younger subjects as long as it is reasonably clean and efficient. When the second bandage is applied, the attitude is somewhat changed, the limb is advanced slightly in front of the plane of the body and at the same time lowered to a moderate degree, the height of the shoe being correspondingly reduced. In cases in which the fixation at the time of the original operation was insecure the anesthetic should be administered in order that one may again test the security of the articulation before lessening the abduction. In certain instances contractions are present that fix the limb and these must be overcome by forced manipulation to permit the change in attitude.

Fig. 1776.—Forcible Flexion of the Extended Limb on the Abdomen. Second step in the operation. (Whitman's Orthopedic Surgery, Lea & Febiger.)

In those cases in which the foot can be brought to the floor, the high shoe may be unnecessary, and the pelvis being tilted downward to accommodate the attitude, more direct pressure is exerted upon the rudimentary acetabulum.

The second period of fixation corresponds to the first in time. Practically speaking, the limb is to be fixed in an attitude to guard against reluxation for from eight months to a year according to the character of the case. The fixation bandage is then removed. In successful cases the attitude of abduction and outward rotation often persists for a time. Massage and exercises, with the aim of strengthening the extensors and abductors of the thigh, are of service in the after-treatment.

By this method of treatment applied in a proper manner, and at the proper time, a large proportion of cures may be attained, approximately from fifty to seventy-five per cent. in unilateral cases in which reduction has been accomplished.

In the unsuccessful cases either the primary reduction was not accomplished or it was not stable. This failure is sometimes not apparent until the limb is brought to an approximately normal position, in others it is evident on removal of the first bandage, the head of the bone lying in an antero-lateral relation to the acetabulum. The reasons for failure, even when all the details of the treatment are carried out, may be classified as:

1. Failure to force the head of the bone through the constricted capsule.
2. The very common anteversion of the neck of the femur that is usually present in anterior displacements and in a large proportion of the other forms. This is caused by torsion of the upper extremity of the femur, and if it is extreme the head of the bone cannot be retained in the acetabulum.
3. Such deformity or non-development that adaptation of the parts is impossible.

The limit of age within which this operation may be successful cannot be stated with certainty. It is evident, however, that the earlier it is undertaken the greater is the chance of success. After the age of eight years the difficulty in reposition is greatly increased and the chances of success are correspondingly lessened. It may be attempted, however, with the alternative of transposing the head of the femur from a posterior to an anterior position and thus improving the balance and the capacity for weight-bearing.

The bilateral dislocation is less favorable for treatment than the unilateral, because the chance of success is in any event lessened by half and because the congenital abnormalities appear to be more marked than in the unilateral class of cases. In young subjects both hips are operated on at one sitting. In older subjects it may be advisable to treat one hip at a time in order to lessen the strain.

The Lorenz operation has been modified by various surgeons—for example, the reduction may be accomplished by mechanical appliances or over the superior instead of the posterior margin of the acetabulum. The limb may be rotated inward and abducted in the extended rather than from the flexed position, and

Fig. 1777.—Forcible Extension of the Thigh. Third step in the operation. (Whitman's Orthopedic Surgery, Lea & Febiger.)

the time of fixation in plaster has been shortened to a few months in certain instances. The Lorenz technique presents the essentials of routine treatment and the modifications are of service rather in the exceptional than in the ordinary cases.

THE OPEN OPERATION.—*Open reduction* is now rarely performed primarily but is reserved for those in which the bloodless reduction has failed.

FIG. 1778.—Reposition. The thigh is forcibly abducted over the padded wedge. Fourth step in the operation. The wedge is of hard wood of the following dimensions: length, 9½ inches; height, 3½ inches; base, 3 inches. (Whitman's Orthopedic Surgery, Lea & Febiger.)

In such cases no preliminary treatment is required, but if the open operation is the primary procedure, all shortening of tissues must be overcome either by traction in bed or by forcible manipulation before the parts are exposed.

The incision is usually made from a point about half an inch to the outer side of the anterior superior spine, and is extended downward and slightly backward for about four inches; the fascia is divided and the line of junction between the tensor vaginæ femoris and the gluteus medius muscles is found. These muscles are then separated and are drawn to either side by retractors, exposing the capsule of the joint. The iliopsoas muscle which often covers its anterior surface is separated from it, and the capsule is caught with a sharp hook and is freely opened by an incision parallel to the neck of the bone. The finger is then passed through the opening down upon the rudimentary acetabulum. A strong cervix dilator is then inserted and the contracted capsule is thoroughly stretched. If the ligamentum teres is present it is removed. If on examination the acetabulum appears to be of sufficient size, the head of the bone is placed within it, the capsule is united, and the wound is closed with catgut sutures. A long plaster bandage is then applied in abduction and extension and the further details of the ordinary non-cutting method are carried out, except that if anteversion of the neck is present the limb must be rotated inward as well as abducted. If it appears that the torsion of the femur is so great as to cause redisplacement, an osteotomy of the shaft of the femur must precede the return of the limb to the normal attitude.

*Osteotomy.*—In order to control the head and neck of the femur a long drill is inserted through the trochanter and to a sufficient distance in the neck to fix it firmly. The child is turned upon the sound side and a sand bag is placed between the thighs. A small sharp osteotome is then inserted on the outer aspect of the thigh at a point just below the trochanter minor, and the femur is divided. The upper fragment being fixed in its place by the drill, the shaft of the femur is rotated outward until the normal relation is restored. In this attitude the plaster bandage is applied about the projecting drill. This is drawn out when the new position is assured, that is, at the expiration of several weeks.

*The Open Operation with Enlargement of the Acetabulum* (the Hoffa-Lorenz operation).—This operation originally devised by Hoffa and modified by Lorenz, as the operation of routine for congenital dislocation, is now reserved for cases in which the simple reposition has failed or in which arthrotomy seems unlikely to be successful.

If when the joint is opened in the manner described the acetabulum is manifestly inadequate, with a strong sharp spoon the contents are removed, and it is then deepened and enlarged to the normal size, particular attention being paid to accentuating its upper and posterior margin.

The head of the bone is then replaced and the stability of the articulation is tested by moving the limb in various directions. The wound is then closed or it may be temporarily packed with gauze according to Hoffa's method. A long plaster bandage is then applied, the limb being extended and slightly abducted. If anteversion of the neck is present the femur should be rotated inward and secondary osteotomy may be performed at a later time if necessary, although stability is often assured by the more capacious acetabulum and by the adhesions. At the end of eight weeks a short spica bandage is substituted on which the child is allowed to walk about.

As might be expected, this operation is always

FIG. 1779.—Reposition in Young Subjects, the Thumb Being Used as the Fulcrum to Reduce the Left Hip. (Whitman's Orthopedic Surgery, Lea & Febiger.)

followed by limitation of motion and there is often a strong tendency to distortion of the limb toward flexion and adduction. It is therefore in this class far safer to fix the limb in extension and abduction by means of the plaster bandage or other appliance until this tendency is overcome, in some cases for a year. In other instances the support may be dispensed with in a much shorter time if methodical stretching and massage can be assured.

When all the symptoms of discomfort have dis-

appeared forcible movements under anesthesia are sometimes of service in breaking up adhesions and increasing the range of motion. Special exercises to strengthen the weak extensors and abductors are of course indicated in all cases.

The advantages of the open operation are that immediate replacement with comparatively little danger of reluxation is assured. The disadvantages are

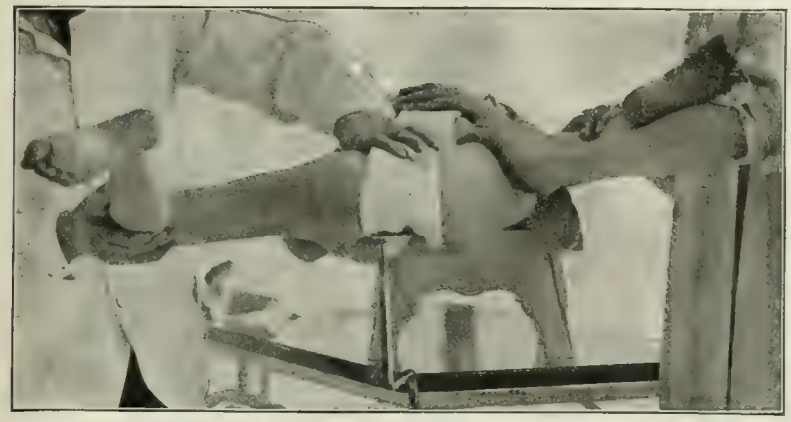

Fig. 1780.—The Position in Which the Limb is Held when the Plaster Bandage is Applied. (Whitman's Orthopedic Surgery, Lea & Febiger.)

the limitation of motion or even ankylosis that may result in those cases in which enlargement of the acetabulum is required.

Ankylosis following the operation in unilateral displacement, provided there is no distortion of the limb, is a marked improvement on the original dislocation, but bilateral ankylosis would practically disable the patient. For this reason one should await the result of the operation on one side before treating the other.

Ankylosis is, however, the exception, and in many instances practically normal, or at all events a sufficient range of motion remains. The degree of final disability depends in great part upon the after-treatment. If deformity is prevented, and if the muscles are strengthened by massage and by exercises, a practical cure may be attained, although in most instances a slight limp will persist even in favorable cases.

The danger of the open operation is slight in the hands of competent surgeons, less even than it is in the other method when great force is required to reduce the displacement, as in the treatment of older children.

In conclusion it may be said that the prospect of success in the treatment of congenital dislocation of the hip stands in direct relation to the age of the patient, since the extent of the pathological changes that make cure difficult or impossible depends in great degree, as in acquired dislocations, upon the duration of the disability. Consequently treatment should be applied as soon as the displacement is discovered, and there is little excuse for not making the correct diagnosis as soon as the child begins to walk. The treatment of selection before the age of six years is the functional weighting method of Lorenz. By this means a large proportion of the cases may be cured, and in all instances the posterior may be changed into an anterior displacement, which always lessens the disability. If this treatment is ineffective it should be followed by the open method. In the younger patients simple incision and forcible stretching of the capsule may be sufficient, if the acetabulum is well formed; if not, it will be necessary to enlarge it to a sufficient size. Osteotomy may be necessary to correct extreme anteversion of the neck of the femur whichever method is employed to reduce the displacement.

The reduction of congenital dislocation of the hip is not likely to be successful after the age of ten years, although in favorable cases it may be attempted, usually, however, with the aim of converting a posterior into an anterior displacement. In exceptional cases in adolescence or in adult life, the discomfort and insecurity may warrant an attempt to fix the head of the femur by an enlargement of the secondary depression on the ilium caused by pressure of the head, or the hip may be excised. In other instances adduction and flexion deformity may require osteotomy to correct practical shortening.

The Shoulder.—Congenital dislocation at the shoulder may occur in two forms, one in which there is actual misplacement before birth, and the other in which a dislocation is caused by violence at birth. In either case the displacement is almost always backward upon the dorsum of the scapula (subspinous). Thus the arm is abducted and rotated inward and there is the characteristic limitation of motion. True congenital misplacement is rare, most of the reported cases being subluxations secondary to obstetrical paralysis.

In these cases in which the chief injury is of the upper cords of the brachial plexus, the original paralysis is of the deltoid, biceps, and the supinators of the forearm. Thus the arm hangs in an attitude of pronation, and later, after recovery in whole or part of the nerve lesion, the attitude of abduction and inward rotation persists, the head of the humerus, in adaptation to the habitual attitude, being subluxated backward, and slightly downward, simulating closely the ordinary form of congenital luxation, or that caused directly by injury at birth.

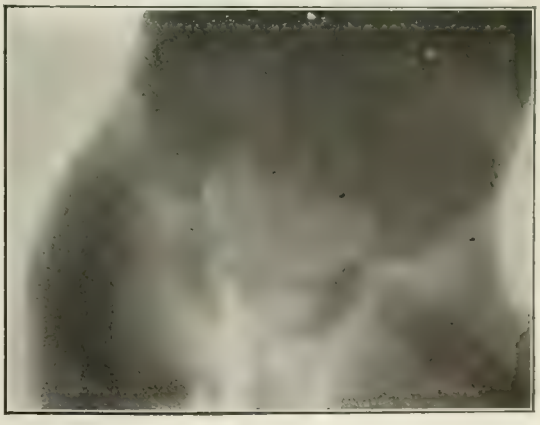

Fig. 1781.—The Attitude of the Limb After Reposition.

*Treatment.*—In either form the treatment is the same in character, namely, to overcome the contractions, to replace the humerus in its socket, to hold it there until the articulation is in part at least reconstructed, the principle being similar to that of the Lorenz treatment of congenital displacement of the hip.

The child having been anesthetized is brought to the side of the table. The shoulder is grasped

firmly to restrain the scapula and with the other hand the arm is drawn upward and backward, the thumb of the hand fixing the scapula forcing the head of the bone forward. This so-called pump-handle manipulation is continued with increasing force until the head is forced forward to its normal position. One then overcomes abduction in the same manner using the thumb in the axilla as a fulcrum until the head is forced upward restoring the normal prominence of the shoulder. Finally the entire limb is

Fig. 1782.—Unilateral Congenital Dislocation, Showing the Fixation Bandage. A shoe with a cork sole about two inches in height should be worn on the operated side, while the attitude of exaggerated abduction is maintained. (Whitman's Orthopedic Surgery, Lea & Febiger.)

rotated outward over and over again in the same manner until the restriction is overcome, and finally it is fixed by a plaster bandage in outward rotation combined with extreme supination of the forearm. In many instances, it is impossible to overcome the contractions completely at one sitting. In such cases the arm is fixed for a week or more in the improved attitude and is finally corrected at a second or third operation when it is fixed in plaster for several weeks. On removal of the splint, the arm must be passively manipulated to the limit of abduction, outward rotation, and supination several times a day, and this must be supplemented by appropriate exercises. Even when extensive paralysis persists the function of the arm may be greatly improved by overcoming the deformity, and in cases of a favorable type it may be practically restored. In rare instances the upper epiphysis of the humerus may be displaced by injury at birth in addition to the brachial paralysis. This may require operative replacement. Operations for the repair of the ruptured cords of the plexus are described elsewhere.

The Knee.—The most common of the congenital deformities at the knee is the so-called genu recurvatum, in which the knee is bent somewhat backward, or, in other words, the leg is hyperextended on the thigh. The deformity is often classed as an anterior dislocation, but there is no actual displacement, except in the extreme cases in which the tibia may be turned directly forward on the femur, even to a right angle or less. In the ordinary cases the range of extension is merely exaggerated, while flexion is limited or checked, principally by adaptive shortening of the quadriceps extensor muscle.

The appearance in well-marked genu recurvatum is very peculiar; it is as if the patient's limb were reversed, the popliteal depression having become a prominence, the range of overextension representing apparently normal flexion. In such cases the leg may be brought to the straight line, but greater flexion is resisted by the retracted tissues, and when the pressure of the hand is removed the leg is drawn back to the deformed position by the contraction of the quadriceps extensor muscle.

Genu recurvatum is not infrequently accompanied by varus or valgus deformity at the knee, more often by the latter, and by laxity of the ligaments. In many instances the patella is absent or is rudimentary, and not infrequently the deformity is accompanied by malformations or defective development of other parts.

*Etiology.*—The deformity in cases of simple genu recurvatum may be explained by an abnormal and fixed position in utero, and in cases seen soon after birth the mechanism is clearly shown by the habitual

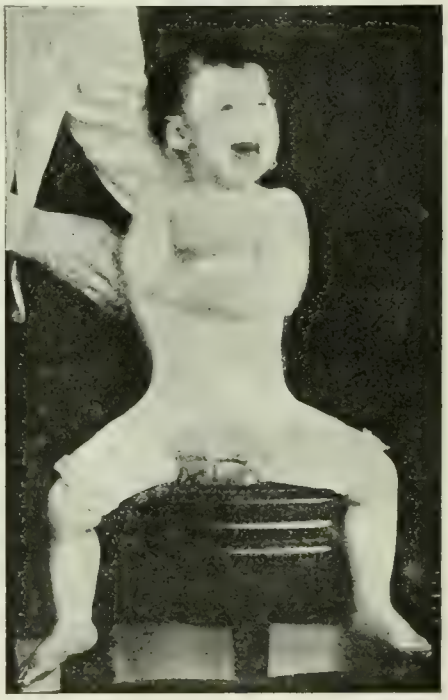

Fig. 1783.—Bilateral Dislocation, Showing the Less Extreme Attitude of the Limbs.

attitude. The thighs are sharply flexed on the body, the dorsal surfaces of the hyperextended knees are in relation to the abdomen, while the feet may be brought into contact with the face or trunk according to the degree of deformity. The retarded development of the quadriceps extensor muscle explains the rudimentary patella which is often an accompaniment of the deformity.

*Treatment.*—The treatment of the hyperextended knee is very simple. It consists in massage of the

atrophied and contracted muscles, combined with more or less forcible manipulation in the direction of flexion. If, as is often the case, the leg seems to be drawn forward by spasmodic muscular action, the methodical massage should be combined with the use of a simple posterior splint.

In the more extreme cases manual force may be applied under anesthesia, and the deformity may be overcome at one or several sittings according to the resistance of the contracted parts. The leg is then

Fig. 1784.—Congenital Dislocation of the Right Shoulder.

fixed in a flexed position until the tendency to recurrence has been overcome. When the child begins to walk a light lateral brace may be necessary to insure perfect functional use of the joint, as in many instances laxity of ligaments and muscular weakness may persist for a time.

Rudimentary or Absent Patella.—As has been stated, a rudimentary patella is a frequent complication of genu recurvatum, or of any congenital defect or deformity of the knee or limb that involves imperfect development of the quadriceps extensor muscle. In many cases of this type it is impossible to distinguish the patella during the early months of infancy, but later a minute patella appears that slowly increases to an approximately normal size.

Absence of patella under the same conditions is less frequent, although Potel collected one hundred cases from the literature.

*Treatment.*—The treatment of rudimentary patella is included in the massage and stimulation of the atrophied or rudimentary muscle with which it is usually associated, and the support that the weak or deformed knee may require. Royal Whitman.

**Dispensaries.**—The word dispensary was originally applied to a small room connected with a physician's office, where the medicines were compounded, but its present meaning is a place or an institution where the sick poor, not requiring hospital care, are examined and treated and are furnished with the necessary drugs or surgical appliances free or for a nominal sum. A dispensary may be the out-patient department of a hospital or it may exist as an independent institution. When the material is used for teaching purposes the dispensary is known as a clinic. It is probable that hospital out-patient departments have existed as long as hospitals themselves—we know that Al Mansur Hospital at Cairo, founded in 1276 A.D., and other Arabian hospitals at that time, had extensive out-patient departments—and there is no doubt that dispensaries also existed before the Christian era, long antedating the establishment of hospitals. Burdett says that in the eleventh century B.C. there was a college of physicians in Egypt the members of which were in receipt of public pay and regulated by law as to the nature and extent of their practice, and it is most probable that the poor were treated by them in institutions corresponding to our dispensaries. Pindarus states that there were dispensaries in Athens in the fifth century B.C. The dispensary physicians were elected by the people and paid by the State, but they confined their activities to visiting the rich and appointed medically educated slaves to attend the poor in the dispensaries.

The first dispensary, distinct from a hospital out-patient department, in London was established in 1770. The first in North America was the Philadelphia Dispensary, opened in that city in 1786; the second, the New York Dispensary, in 1790; the third, the Boston Dispensary, in 1796; and the fourth, the Baltimore General Dispensary, in 1801.

For a discussion of the plan of organization of dispensaries, see the article on *Hospital Organization and Management*. T. L. S.

**Disporocystidæ.**—A family of the Coccididiea in the Sporozoa in which the oöcyst has two spores. The genera are *Cyclospora*, *Diplospora*, and *Isospora*. The last is the only genus which is found in man. See *Protozoa*. A. S. P.

**Dissection and Operation Wounds.**—The class of wounds to be considered under the title are those wounds received in the course of surgical operations, or of postmortem or other anatomical dissections, which induce in the wounded subject a more or less grave condition of local or general sepsis. Such wounds are generally received upon the hands or forearms, and with special frequency upon the fingers of the left hand, but, except in unimportant particulars, the seat of the original infection has no special bearing upon the course or the character of the ensuing disease, which, when it passes beyond the status of a local inflammation, is essentially a pyemia, a septicopyemia, or a septicemia, differing in no essential respect from these diseases occurring as the result of infection received in divers parts of the body, and in the pursuit of the most varied occupations.

Etiology.—In investigating the etiology of dissection and operation wounds, a microbial origin will be taken for granted without further discussion, and we shall proceed to consider, first, the nature of the infecting microbe; secondly, the effect upon its virulence of the source from whence it comes; and thirdly, the different types of disease the various infecting germs are prone to engender.

*The Nature of the Infecting Microbe.*—That the foremost place as an infecting agent is to be assigned to the *Streptococcus pyogenes*, is to be inferred from our knowledge of septicemic and pyemic processes in general, induced through other means than by the performing of surgical operations and anatomical dissections, rather than to be gathered directly from

the somewhat sparse records in medical literature of cases in which a bacteriological examination "en règle" has been reported. One decisive case of streptococcus infection is recorded by Harrington,[1] and is reported below.

The *Staphylococcus pyogenes aureus* is, probably, the next most frequent organism which can give rise to the septic processes we are considering. Though sometimes found in pure culture in dissection and operation wounds, it is perhaps still more frequently found in these lesions in association with the preceding.

It is hardly to be doubted that any and all of the well-recognized pyogenic germs may, under favorable circumstances, give rise to a more or less virulent septic process, if inoculated on the hands of the surgeon or the pathologist. The minor pyogenic germs, *Staphylococcus albus, citreus cereus flavus, epidermidis albus*, etc., do not ordinarily manifest a sufficient degree of virulence to occasion severe dissection or operation wounds, even though they may sometimes cause some local inflammation.

Outside of the germs more frequently included under the head of "pyogenic," the anthrax bacillus may be mentioned as one apt to occasion a condition which would properly come under our title. I have no record of a case in which anthrax infection has occurred either during a surgical operation or during a postmortem examination, yet Gaston alludes, rather indefinitely, to a case in which inoculation with anthrax occurred as the result of the breaking of a culture tube containing the bacilli.[2]

The bacillus of malignant edema, which in many respects closely resembles that of anthrax, would likewise seem peculiarly apt to cause infection of operation wounds: yet we have the authoritative statement of Welch (1895) that "no instance is recorded of infection of a previously healthy person with this bacillus."[3] One of the French names for the disease it induces, "gangrène foudroyante," describes a condition occasionally characterizing dissection and operation wounds.

The *Bacillus tuberculosis* is notoriously the occasion of infection in the so-called "anatomical tubercle," or "necrogenic wart," which is prone to appear on the hands of those frequently employed in the dissecting-room. The occurrence of a local or general tuberculous process as the result of an infection during a surgical operation I have not been able to find recorded, but both local and general tuberculosis, arising from accidents to the fingers and hands in the bacteriological laboratory, are believed to be not uncommon.

The *Bacillus coli*, the *Diplococcus pneumoniæ*, the gonococcus, the bacillus of Eberth, have been known to cause pyemic abscesses and have been found in the blood in some forms of septicemia; that they should, however, gain access to the tissues during operations or postmortem examinations, and be able to multiply there in such a way as to occasion sepsis, seems, on the whole, unlikely.

The Klebs-Löffler bacillus, or *Bacillus diphtheriæ*, has frequently been the occasion of more or less severe diphtheritic processes following inoculations acquired during professional attendance upon diphtheritic patients. In one instance under the writer's observation, a sluggish and painful ulcer of the eyelid, which yielded a pure culture of this organism, followed an examination of a child's fauces, in which the patient had coughed in the face of the physician at the moment of the examination.

The virus of syphilis has repeatedly evoked a primary chancre on the hands and fingers of surgeons.

In many cases, as notably in that of Professor Park, detailed below, it has not been possible to identify the infecting agent, and in many cases also a mixed infection has been passed on from the patient to his physician, or has been acquired during the performance of autopsies.

*The Effect upon the Virulence of the Infecting Germ of the Source from Whence it is Derived.*—Accurate statistical information on this particular branch of our investigations I have not had the opportunity to collect; indeed, the sparse records of dissection and operation wounds to be found in medical literature, of sufficiently recent date to throw any valuable light on this question, are remarkably deficient in their reports as to this phase of the problem. In considering the enormously enhanced virulence of the pathogenic organisms which we occasionally encounter in dissection and operation wounds, we are again driven to inferences derived from observations of the broad and complicated subject of the virulence of pathogenic bacteria in general, and I must content myself with some suggestions as to possible conditions which may enhance the virulence of the germs in question, rather than proceed to report a categorical list of recorded cases.

I would call attention, in the first place, to the means commonly made use of in the bacteriological laboratory to exalt at will the virulence of any given form of pathogenic germ, namely, the expedient of passing the organism through the body of a susceptible host. Particularly are the streptococci thus susceptible of manipulations calculated to enhance their virulence. To cite but a single instance of a well-known procedure, Denys and Marchand, in studying the *Streptococcus pyogenes*,[4] procured samples of these germs from four different sources, all four of very slight virulence, and for the purpose of comparing the effects of the inoculation of mild cultures with those of virulent cultures, multiplied the virulence of the original cultures by this means, until the increase in virulence, as measured by the size of the minimum fatal dose, was expressed by a factor not less than 10,000. Nothing, however, is ordinarily more difficult than to maintain this condition of exalted virulence in cultures grown in artificial media; each successive generation grown "in vitro" showing a great and progressive diminution in virulence.

Now it is this well-known attribute of the pyogenic bacteria which affords us a key to the enormously exaggerated virulence sometimes evident in the infecting agents of dissection and operation wounds.

We are daily made familiar with the occurrence of sepsis, more or less profound, occasioned by the infection of slight abrasions and minute wounds of the fingers and hands with pyogenic cocci inoculated by contact with inanimate objects; this "filth infection" may be very severe, and is occasionally fatal.

Let us once consider a case in which pyogenic bacteria, streptococci, if you choose, growing upon a splinter of wood, constitute a source of infection which we will call A; let us suppose that a mechanic infects his hand from this splinter of wood, and becomes himself, through the means of a "cellulitis" induced by these streptococci, a second source of infection, B. Let us further suppose that a culture is made from the mechanic's wound; after this culture has grown a certain length of time in a test-tube, this becomes a third source of infection, C.

Now let us examine the comparative virulence of the three sources of infection: A, the "filth-infection"; B, the "direct infection"; and C, the "test-tube infection." The virulence of A we know, for we have just supposed it to have produced a more or less severe cellulitis on the hand of the mechanic. Let us suppose now, further, that the surgeon who dresses the mechanic's hand himself receives a minute scratch in the operation, and that this scratch is directly infected from the source B; the presumption is that a severe, possibly a fatal, septic process would develop in the person of the surgeon. Again, let us suppose that the bacteriologist (he, the surgeon, and the mechanic being equally robust men, with normal powers of resisting infection) breaks his test-tube and cuts himself with the glass, infecting himself with the

same germs, but from source C; the presumption, in this case, is that he would suffer from a septic process approximately equal in severity to the cellulitis on the hand of the mechanic; *i.e.* in undergoing culture on an artificial medium, the septic germs would be liable to lose again the increment of virulence which they may be supposed to have acquired in passing through the human body; but, as we have seen in the case of the surgeon, direct inoculation from the septic focus on the hand of the mechanic manifests a very decided increase in the virulence of the germs, an increase acquired by their passage through a susceptible host.

This is what I conceive to be the essential difference, as far as an essential difference may be conceived to exist, between an ordinary case of septic infectiod and a "dissection or operation wound."

When we dwell upon the numerical size of the factors by which the virulence of a given germ may, under some circumstances, be multiplied—10,000; 100,000; or even 1,000,000—we can form a conception of the extreme degree of virulence which some cases of direct infection, from man to man, may present.

The cruder ideas of wound infection, as being analogous to the simple process by which a sterilized infusion undergoes putrefaction when a single suitable germ is introduced, have been superseded, now that fuller investigation has shown the elaborate means of defence with which our bodies are provided to enable them to ward off the deleterious effects of pathogenic germs; and we can now better appreciate what powers of noxious influence a germ must possess which succeeds in overcoming all these barriers, and in accomplishing the undoing of a man or an animal.

It is a well-known biological law that exaltation of functions comes from their successful exercise. We speak of the acquired immunity of a man or of an animal to the noxious powers of certain germs, and we understand thereby that his defensive proteins either are present in greater quantity, or have acquired a higher potency. It is just as logical, however, to speak of the acquired immunity of a germ to the (to it) noxious powers of the human or the animal cells, and we may properly understand thereby that the analogous proteins of the bacteria, what we may call the "offensive proteins," either are formed in greater relative quantity, or have acquired a higher degree of virulence. Just as a man who has successfully struggled with the germ of typhoid fever is generally immune to attacks of the bacilli typhosi in the future, so a streptococcus which has succeeded in vanquishing the opposition to its development offered by the cells and by the agglutinins and the bacteriolysins in the serum of a human body may be conceived to carry with it an "acquired immunity" to the influence of such cells and such serum, if it pass directly from one human subject to another. (Flexner.[5]) And the more complete the victory of the germ over the human body cell, the more complete the "immunity" acquired by the germ against the defences of the human organism; and, ergo, the more apt is the germ to induce a grave type of infection, always provided the transmission is direct from one human host to another. Now, by way of illustration, bone marrow has been ascertained, by Wauters, to contain larger proportions of bactericidal substance than any other tissue of the body;[6] we may thence infer that bacteria which have succeeded in gaining a foothold in the bone marrow itself will be found to be possessed of a high degree of virulence, and we may accordingly expect to find, as indeed we do, that direct infection from a case of acute osteomyelitis will be apt to be very grave. Again, the highest stage of the triumph of pyogenic germs over the animal body is seen in the conditions known as septicemia and pyemia, and it is in just these cases that we find the danger of direct inoculation at a maximum.

In further support of this argument, as tending to show its converse, we may mention the fact that often, in cases in which the human or the animal organism is ultimately victorious over the germ infection, it is found that cultures taken at the beginning of the struggle are more virulent than those taken from the same case later on in its course, when a portion of the virulence of the infecting organisms seems to be overcome; *e.g.* a beginning carbuncle may afford germs of far greater virulence than one over which the defences of the organism have in a measure successfully asserted their power.

We can now understand why it should have been universally observed that inoculations from severe septic cases are more prone, than those from the lighter forms of sepsis, to give rise to the type of surgical disease which is the subject of this article. Puerperal fever, pyemia, septicemia, carbuncles in their acute stage, malignant erysipelas, acute osteomyelitis, phlegmonous cellulitis, and suppurative peritonitis are most frequently named as the origin of dissection and operation wounds, whether from surgical operations proper, from surgical dressings or from postmortem examinations. These germs, when inoculated directly from man to man, occasionally, even if rarely, acquire an enormously enhanced virulence, exhibited at its maximum, however, only in cases of direct inoculation. Infected knives, sponges, dressings, or other objects may indeed carry the infection for some days, or even weeks, if not properly disinfected, but it is probable that the full degree of virulence that attends direct inoculation at the time of operation, or at the moment of a postmortem examination, would not be manifest in an infection conveyed by the same germs at a later period, after the lapse, that is, of an interval during which the germs, even if surviving, were exposed to influences such as desiccation or chilling, comparatively unfavorable to their existence, or at least to the maintenance of one of their unstable characteristics, their virulence.

On this same basis, likewise, is to be explained the notable difference in the comparative danger of a wound received at a recent, with one received at a delayed, autopsy. In the first case, the remaining bodily warmth and the absence of the further development of the defensive proteins on the part of the dead subject, allow the bacteria to develop under conditions most favorable for their growth; in the second case, the chilling of the body and, likely enough, the beginning decomposition of the tissues, and the struggle for existence with saprophytic bacteria, so affect the environment as to yield a less suitable culture medium for the pyogenic germs, which, continuing indeed to grow, yet develop under less favorable circumstances, and consequently lose that acme of virulence which manifests itself only under peculiarly favorable conditions of growth.

A phenomenon analogous to the greater danger of direct, man-to-man infection as compared to indirect filth infection, lies in the well-known occasional virulence of the bites of animals. Here, too, septic conditions are sometimes communicated in which germs are directly transferred from one host to another, in a condition of "exalted virulence"; indeed, the bite of a man is not less dreaded than that of some of the lower animals.

Cases of exalted virulence of the infecting germs, due to direct transference, were not infrequently seen when "arm-to-arm" vaccination was still in vogue, where apparently healthy children communicated severe disease to others.

The experiments of Fehleisen tend to show another reason for the greater danger of "direct inoculation" as compared with "filth infection." This observer showed that a minimal quantity of an artificial culture of *Staphylococcus aureus* added to a little of the clear serum obtained from the germ-free zone of inflammatory edema around a spreading cellulitis,

was capable of producing extensive abscesses, whereas the mixture of the same organism with water had no effect. The inference is that the bacteria, in the first case, were accompanied by their toxins, and entered the contest armed, as it were, for the fray; while in the second case, the bacteria were washed free from their toxins, and were unable to gain a foothold in the tissues until their toxins were again secreted in sufficient quantity to weaken the defence of the tissue cells; in the case of these particular experiments, the staphylococci employed were unable to do this in time to prevent their destruction by phagocytosis. Now, in cases of direct inoculation, the bacteria will be more likely, than in cases of filth infection, to be accompanied each with its minute quantum of toxins, which will enable them to increase and multiply, where similar germs, without the accompanying toxins, would be exterminated.

In conclusion let me say that to ascribe, as some were inclined to do, when the germ theory of disease was younger, a special and peculiar infecting agent to dissection and operation wounds, on account of their occasional extreme virulence, is entirely gratuitous and uncalled for. Ample explanation can be given for all the phenomena observed, if we distinguish clearly between the differing possibilities of gravity in cases of direct inoculation, as compared with ordinary filth infection.

Having now considered the nature of the germs which give rise to dissection and operation wounds, and the effect upon the virulence of the infecting germs of the source from which they are derived, it behooves us to consider:

*The Types of Disease These Infecting Germs are Prone to Engender.*—Of the germs which were mentioned as possible causes of dissection and operation wounds, it is unnecessary to describe the type of disease which would be likely to follow the inoculation of the more specific forms; the anthrax bacillus, the bacillus of malignant edema, the tubercle bacillus, and the bacillus of diphtheria would all of them be likely to give rise to more or less characteristic lesions, whose description may be sought under the appropriate headings elsewhere in this work. The virus of syphilis would give rise to a hard chancre. Indeed it is doubtful whether the lesions which these germs produce are properly classed under our heading, and they are mentioned rather for the sake of rounding out the subject than for their actual importance as frequent causes of dissection and operation wounds; and we shall not have further occasion to consider them here, as we shall confine our future discussion to lesions caused by the pyogenic germs proper, whether in pure or in mixed infection.

Now the name "pyogenic" implies that the most characteristic result of infection with these germs is the formation of pus; yet though this is the characteristic outcome of such infections, this result does not always follow, nor yet is its appearance, in any true sense, a measure of the virulence or of the gravity of the infection. Suppuration, indeed, represents the most intense and complete *local* action of these bacteria, but the less advanced forms of inflammation are always precedent stages of suppurative action, and very extensive and dangerous lesions may fatally compromise the vitality of the patient without the presence of pus in any one focus; this, too, with staphylococcus infection, with streptococcus infection, and with mixed infections of the two germs. Says Welch[8]: "All of the affections caused by one species of the pyogenic cocci may be caused by any of the others. For example, the *Staphylococcus aureus* may produce spreading phlegmons, inflammations of serous membranes, puerperal infections, general septicemia, as well as the *Streptococcus pyogenes*, and the *Streptococcus pyogenes* may cause circumscribed abscesses and osteomyelitis, as well as the yellow or white staphylococcus. Jordan claims that the *Staphylococcus aureus* may cause erysipelas, but Petruschky does not regard his observations on this point as conclusive."

"Furthermore, these pyogenic staphylococci and streptococci may cause all kinds of inflammation besides the suppurative. They may, and often do cause serous, serofibrinous, and fibrinous inflammations of serous membranes. The *Streptococcus pyogenes* may cause catarrhal and fibrinous inflammations of mucous membranes. Pyogenic cocci may be the sole cause of simple inflammatory edema or serous infiltration of the tissues. They are sometimes found in cutaneous vesicles and blebs containing clear serum. They may be the sole organisms present when the inflammatory exudate is hemorrhagic. They may produce extensive necrosis of the tissues with scarcely any inflammatory exudate. We find the same staphylococci and streptococci in those rarer forms of osteomyelitis which do not suppurate, as in the ordinary suppurative form. They are the usual cause of periostitis and ostitis albuminosa, in which the exudate is serous. A serous or serofibrinous inflammation caused by pyogenic cocci may be transformed into a purulent one without the appearance of any new species of microorganism."

While we recognize, as above related, the great variety of lesions to which the pyogenic cocci may give rise, and also the fact that any of these protean forms of disease may, with the possible exception of erysipelas, be occasioned either by the *Staphylococcus aureus*, or by the *Streptococcus pyogenes*, or by a mixed infection of both germs, yet, nevertheless, the more typical characteristics of infection by one of these germs, as distinguished from the other, can very often be made out. It is the general tendency of the staphylococcus to form circumscribed abscesses, surrounded by a distinctly marked zone of dense inflammatory exudate; while it is equally the tendency of the streptococcus to excite spreading phlegmonous processes along the connective-tissue planes, and to invade the lymphatic vessels and glands.

Mixed infections of the two cocci may take on the characteristics of both, or may follow the type of either one. Mixed infections, when either the staphylococcus or the streptococcus is in combination with some other non-pyogenic form of bacteria, may follow either the staphylococcic or the streptococcic type, or may present a more confused type of inflammation. The importance of distinguishing, if possible, the cause of the infection lies in its bearing on the prognosis, which becomes most grave in the presence of the streptococcus, and secondly in its bearing on treatment by means of suitable vaccines.

Pathogenesis.—We shall consider under this head, first, the type of wound by which infection is prone to occur; secondly, the condition of the constitution which favors spreading of the infection; thirdly, the various forms of internal resistance offered the advancement and multiplication of the microbes; and fourthly, the means of eliminating the microbes and their products from the system.

*The Type of Wound through which Infection is Prone to Occur.*—As a matter of fact, the wounds through which septic infection has been received during the performance of surgical operations and postmortem examinations, have been, for the most part, in themselves most trifling; generally slight scratches or abrasions, superficial cuts, punctures from needles, and, in a not inconsiderable proportion of cases, lesions either literally microscopic, or so small as to defy discovery after minute examination; a not uncommon cause is the cutting of the skin of the surgeon's finger by the pressure of a fine silk or catgut ligature in tying knots.

Inasmuch as other types of wounds, as a matter of

fact, do not occur under the circumstances, we are not able to institute comparisons between the behavior of one type or of another type of operation wounds, but there are some reasons which lead us to suppose that the type of wound ordinarily received during surgical operations and postmortem examinations is not without influence upon the subsequent development of sepsis in their recipients. Two reasons would lead one *a priori* to suppose that the class of wounds above would be more prone to permit the development of severe sepsis than deeper or more extensive traumata, and of these the first has reference to their *superficial position.*

Especially in cases of slight abrasion of the skin, the infecting bacteria are apt to be implanted directly into the cutaneous lymph channels. Now three several circumstances combine to make such a lodgment of the bacteria one particularly favorable to their subsequent development. First, the most dreaded type of infecting germ, the *Streptococcus pyogenes*, has notoriously its favorite habitat just here, as it will be remembered that not only does the streptococcus tend in general to accumulate particularly, and sometimes almost exclusively, in the lymph spaces, but that the invasion of the cutaneous lymph space is *par excellence* the attribute of this streptococcus, which is now generally conceded to be identical with the *Streptococcus erysipelatis* of Fehleisen.

Secondly, aside from the specific type of the infecting germ, experiment has indicated, with other forms of bacteria also besides the streptococci, that actual infection of the organism occurs via the lymph channels. The following experiments have been instituted to demonstrate this conclusion:[9] Rabbits were first inoculated on the tip of one extremity with anthrax cultures, and observations were made as to the length of time necessary for the bacilli to reach the lymph glands; a certain number of observations established more or less exactly the time necessary for this to occur. The extremities of other rabbits, similarly inoculated, were amputated before the lapse of the minimum time necessary for the anthrax bacilli to reach the lymph glands; these animals survived, while those whose extremities were amputated after the critical time perished. The inference drawn is that infection must occur through the lymph channels and not through the sanguineous circulation, else amputation of the extremity had not rescued the inoculated animals. Though this can hardly be said to constitute rigid proof that pyogenic infection constantly occurs in this way, yet it gives ground for the suggestion that a slight abrasion opening the lymph channels without affecting directly the deeper tissues might afford an exceptionally favorable portal of entry to septic germs. The experience of public vaccinators in general would seem to support this same idea, inasmuch as they assure us that vaccination is far more likely to "take" if the scarification of the skin, for the purpose of introducing the vaccine, is not made sufficiently deep to occasion actual bleeding.

The third circumstance, which makes a superficial wound or abrasion one which is prone to septic involvement, is the circumstance that, from the mere fact of its superficiality, it is in a measure removed from the defensive apparatus of the animal economy, and germs there entering are less freely exposed, than those deeper ensconced, to the protective influences of chemotaxis and phagocytosis. Germs implanted in the connective tissue proper have far less chance of survival than those introduced directly into the cutaneous or other lymphatic channels. Not only the observations of Wauters, already referred to above, but those also of Marmorek and of others, have established the fact that the connective tissue is the most efficient defender against bacterial invasion, owing largely to the fact that this tissue contains in itself a comparatively high proportion of actively bactericidal substance. But Marmorek further asserts that the observed fact of the unstable foothold obtained, as a rule, by pathogenic germs in many parts of the body, depends not only on a special antibacterial force, but is also in close relationship with strictly anatomical conditions. When the bacteria have once succeeded, owing to the prevalence of their virulence or of their number, in overpassing the zone of protective infiltration in the connective tissue, they have, *ipso facto*, overcome the "first system of defence" at that point. They then, at length, obtain a foothold in a lymph vessel, and thence extend themselves to the lymph glands; the lymphatic system he regards as the organ of the "second line of defence."[10] Thus, pyogenic germs inoculated immediately into the cutaneous lymphatics are introduced within, or we may say behind, the outer defences of the body, and so are, in a measure, relieved of a portion of the combat for supremacy with the cells of the animal microcosm.

The second reason which should render wounds of the type ordinarily received during surgical operations and postmortem examinations specially prone to septic involvement, is the fact that they are likely to present a maximum of virulence, in conjunction with the important condition of a minimum of mechanical or chemical trauma. Trauma elicits inflammation, which is substantially the sum of those actions by which the animal organism brings into play its defensive apparatus against microbial or other harmful invasion. Diapedesis, serous effusion, fever, and pain (inducing immobilization of the affected part) are defensive means spontaneously brought into play in the presence of any extensive trauma; all these are far less active in the case of minute wounds, than in that of injuries of greater magnitude. The relation between the extent of the local reaction at the point of inoculation on the one hand, and the duration of life and number of organisms present in the blood on the other, have long been recognized in the experimental septicemias of the lower animals.[11] Just as we find that many of the defensive proteins, the specific opsonins, agglutinins, precipitins, and bacteriolysins are not manufactured by the animal organism except as a reaction to specific antigens afforded by invading bacteria so it is not unreasonable to suppose that certain of the "offensive proteins" of the invading microbes may not be manufactured by them, except in the face of opposition to their growth exhibited by the defensive activity of the animal cells, and that when these "offensive proteins" which represent specific antigens, are not thrown out, a defensive chemotaxis is less actively evoked, the opsonins, agglutinins, etc., are less abundantly supplied, and the virulent bacteria, insidiously implanted, may continue to multiply unopposed, until they have acquired a reserve power for attack which they might never have attained had their inoculation been attended with more extensive traumatism.

*The Condition of the Constitution which Favors Spreading of the Infection.*—The question of the condition of the constitution which favors the spreading of the infection in dissection and operation wounds is most intimately connected with the doctrine of mixed infections. Aside from the well-known fact that a generally debilitated condition of the body, such as is produced by insufficiency in food and rest, protracted anxiety and nervous strain, and prolonged exposure to cold and other influences more or less powerfully depressing to the resisting forces, and the coexistence of such diseases as diabetes, syphilis, alcoholism, anemia, obesity, typhoid and other fevers, Bright's disease, etc., some of which have been shown, upon most conclusive clinical evidence, to be predisposing causes of infection with the pyogenic cocci, we must give proper weight to the conditions of enhanced virulence that may develop as the result of the concurrent development in the tissues of

two distinct forms of bacteria. Whereas this association may be without special influence as regards infection, yet more frequently the concurrent inoculation of two species of bacteria increases the danger from one or both. "A combination of two species, each in itself harmless, may prove fatal" (Roger). A bacterium of attenuated virulence may become augmented in virulence by inoculation in combination with another species, which need not necessarily be itself pathogenic, or sometimes simply in combination with the *chemical products* of another species.[12] Nor is it essential to the appearance of enhanced evil effects that the inoculation of such independent growths be simultaneous. There is no lack of clinical cases to illustrate the occurrence of severe pyogenic mixed infections, in which, in one set of cases, the pyogenic process was latent or in abeyance, and was roused to extreme or even fatal activity by the admixture of a fresh, non-pyogenic infection; and in another set of cases, a previously latent non-pyogenic infection, when later mingled with an infection of pyogenic type, gave rise to the gravest manifestations of sepsis. The influence, in this regard, of epidemic influenza has been recorded by Bennett, in four cases, which we can but briefly glance at.[13]

Case I. Simple synovitis of the knee, almost well, influenza, suppuration, pyemia, amputation.

Case II. Cystitis, improved, urine suddenly excessively fetid, after forty-eight hours of influenza, obstinate cystitis, pyemia.

Case III. Patient apparently convalescent from influenza noticed swelling and redness about a small crack in lower lip. Erysipelatous inflammation followed, with abscess over right side of face and throat. A few days later, pneumonia and secondary pyemic deposits over right knee and left thigh, followed by sudden filling of left knee joint.

Case IV. Urethral stricture, facial herpes followed by influenza, erysipelatous inflammation, pyemia.

The influence, on the other hand, of a preexisting stercoremia, a "bad cold," or other mild, non-pyogenic infection, as a cause predisposing to pyogenic infection, is so generally recognized as to make any more specific citation of cases superfluous.

Now how frequently is the surgeon or the pathologist obliged to continue his work when himself suffering from many such mild ailments, yet how considerable a bearing they may have on the outcome of an accidental inoculation with pyogenic germs during operation or autopsy is scarcely appreciated until the unexpected happens, and a trifling injury is seen to take on all the aspects of a virulent local, or even general, infection.

*The Various Forms of Internal Resistance Offered to the Advancement of the Microbes.*—It is not within the scope of this article to elucidate the whole pathogenesis of pyogenic infection, yet a proper understanding of the dire results which may follow upon a slight dissection or operation wound demands that we should at least briefly follow the history of the microbes which have been inoculated with the receipt of the wound.

The "cytomachia" which follows the introduction of pathogenic bacteria among the constituent cells of the animal or human economy, is but a single, limited, yet intensely interesting phase of the general biologic phenomenon of the struggle for existence. In one sense, indeed, it is the struggle of the individual animal, as a whole, against an opposing entity, the invading disease; yet in a sense equally true, but only appreciable to us since the recent advances of scientific investigation, it is the struggle of a countless number of individuals of an invading host, against countless numbers of individual cells acting on the defensive. Looked at from this latter point of view, it is a struggle of cell against cell and a crossing of cell weapon with cell weapon. The invading hosts are the pathogenic bacteria, and their weapons are, what I have ventured to call, the "offensive proteins." These "offensive proteins" are chiefly of two kinds, the toxins, and certain proteolytic substances (ferments?), capable of causing the death and disintegration of the body cells, but yielded up only at the death of the individual bacteria. The defending hosts are the militant cells of the animal body, chiefly the leucocytes and certain comparatively undifferentiated connective-tissue cells, the so-called "Schlummerzellen," and the defensive proteins are chiefly of two kinds, the antitoxic proteins, directed against the "offensive proteins," *i.e.* against the toxins (antitoxins); and the proteolytic (antimycotic) proteins (antitoxins and precipitins) directed against the invading bacteria themselves (opsonins, agglutinins, bacteriolysins), and capable, under favorable circumstances, of causing their death and disintegration. Beside this "long-distance" combat, the analogy with human warfare is still further borne out by the actual grappling of individual cell with individual bacterium. In some cases this represents the attack of the bacterium on the leucocyte (*e.g.* the gonococcus); more often it represents the attack of the leucocyte on the bacterium, and the phenomenon is then known as phagocytosis.

In the conflict between animal cells and bacteria all these factors are simultaneously or successively brought into play, and certain forces prevail and predominate over other forces, until victory, at least temporarily, rests with one party or with the other.

According to the relative predominance of one or more of the embattled forces we have one or another pathological picture before us. One of the earliest and the commonest pathological phenomena which are observed to follow the invasion of the animal body by pathogenic germs, is active or inflammatory edema. This is the result of what is known as chemotaxis, the marshalling of the forces of the defence; the leucocytes in vast numbers assemble on the field of battle to engage the invading bacteria, and the vascular system responds with dilatation of the vessels and accumulation, in the intervascular interstices of the tissues, of serum charged with defensive qualities.

Another common phenomenon is localized suppuration and abscess formation. Here the leucocytes have not only assembled but have actually engaged the bacteria, and with the death of their foemen, or of members of their own forces, there have been liberated the proteolytic substances which have caused the liquefaction of the surrounding tissues.

Though the pus within an abscess cavity may swarm with bacteria, yet not infrequently bacteria in such pus are few, or may be altogether absent, *i.e.* the pus is "sterile" (suppurating buboes, tuberculous abscesses, gonorrheal salpingitis, empyemic exudates). In the first case the abscess has been more or less immediately caused by the bacteria, and they have "slain their thousands" among the leucocytes, the bodies of the defunct leucocytes have become dissolved through the action of the proteolytic ferments and only sparse, disembodied nuclei, but faintly dyed by staining reagents, are to be found in the fluid; such pus is thin and watery, it is spoken of as "ichorous" pus, and has long been recognized as "acrid," "erosive," and "virulent," *i.e.* it contains many victorious bacteria. In the second case, on the other hand, the suppuration has been evoked more or less immediately by the leucocytes, which by an exaggerated chemotaxis have crowded about the invading bacteria and have overcome them, some by phagocytosis, some doubtless by means of the antimycotic proteins (agglutinins, bacteriolysins); such pus is thick and creamy, contains plump, distinctly nucleated "pus cells" (polynuclear leucocytes) and is known as "laudable pus," and recognized as far less virulent and acrid, *i.e.* it contains few (sometimes none at all) debilitated and attenuated bacteria.

Another phenomenon occasioned by the invasion of the tissues with pathogenic bacteria is more or less extensive necrobiosis and sloughing. Here is a case in which the toxic influences of the bacteria have been locally exercised to a more extensive degree than the leucocytes immediately engaged have been able to cope with, and larger or smaller masses of the less energetically vitalized tissues, in the neighborhood of the focus of invasion, have been literally poisoned to death by the concentrated toxins. This is generally, but not always, accompanied by more or less suppuration of either the first or the second type; we deem it to be of the first type when the sloughing is progressive (necrosis progrediens); of the second more benign type when the sloughing is not progressive, but is rather the benign effort of nature to expel useless tissue by a process, as it were, of spontaneous amputation.

Again, in another case, the best efforts of the defending leucocytes are barely equal to the task of holding in check the local development of the bacteria, but the latter nevertheless produce their toxins in such quantity that the antitoxins and precipitins of the blood are no longer sufficient completely to neutralize them, the unneutralized excess of bacterial toxins circulates in the blood serum, and the profound intoxication, which we saw involve the death of vulnerable tissues in the immediate neighborhood of the focus of invasion, exerts a similar, but happily generally a less intense, effect upon all the tissues of the organism; toxemia is the result, with headache, vomiting, general malaise, and the system generally reacts against the wholesale poisoning of its tissues, with fever; yet in the more malignant intoxications such widespread and profound intoxication of the tissues may be produced that the individual succumbs at once, without any reactionary fever, without suppuration, sometimes even before marshalling of the forces of the defence by chemotaxis, "septicémie foudroyante"; the whole drama is ended in a few days or even a few hours, with a normal or even a subnormal temperature, and without reaction to the overwhelming dose of the toxins.

A still higher triumph of the invading bacteria over the defences of the body is manifested when the former not only send their unneutralized toxins coursing through the veins, but themselves escape bodily through the second barrier of defence constituted by the lymph channels and lymph glands, and, mingling with the blood corpuscles in the blood-stream, continue to grow there, and in the very bosom of the life fluid itself multiply their numbers and evolve their noxious products. This condition, that of septicemia *strictiori sensu*, is most typically developed in the specific experimental septicemias of the lower animals, in which, after the inoculation of the specific virulent germs, these are presently found swarming in countless numbers in the blood of the victims. In this aggravated form this invasion of the blood with pyogenic bacteria is rarely, though indeed occasionally, seen in man (*vide infra*, Case IV.), but in the human subject analogous symptoms are developed when even a few pyogenic cocci are discernible in the blood after careful examination. It would seem that bacteria having sufficient vitality to establish themselves and multiply within the blood are nearly beyond the reach of effective attack by the animal defences, and cases in which pyogenic cocci, especially streptococci, have been demonstrated in the circulating blood must be regarded as having a very grave prognosis, unless extraordinary aid can be afforded to the defensive apparatus of the patient. Nevertheless, battle is sometimes offered the pyogenic bacteria even within the blood-vessels, and the severe chills and enormous excursus of the temperature curve indicate the desperate character of the conflict waged by the defensive cells. The cells die in multitudes and in expiring bring into play their most powerful weapon, the antimycotic proteins (bacteriolysins and general proteolytic ferments). Now along with the leucocytes (the militant cells of the blood) numbers of the red blood corpuscles also undoubtedly succumb in conditions of severe sepsis, and a fibrinogenous substance, metaglobulin,[14] is developed, a product of the disintegration of cell protoplasm, which has the attribute of inducing coagulation of the blood and thrombus formation. In these thrombi the battle is renewed much as it was first fought in the connective tissues, and each separate thrombus becomes immediately invaded with septic germs, and becomes converted into a suppurating focus, a pyemic abscess. As the invading bacteria successively invade each new thrombus, and cast a fresh load of toxins upon the staggering forces of the patient, the event is heralded with a chill, the characteristic phenomenon of a pronounced pyemia. The struggle is now continued for a time, at an almost hopeless disadvantage, until death, either from exhaustion or in profound septic intoxication, closes the scene.

Leaving for other articles in this work to give the further details of the process of septic infection which we have thus broadly sketched, it must suffice us, in considering the development of dissection and operation wounds, to familiarize ourselves with the following general conclusions of Marmorek in regard to them, as a limited subclass of general or local septic infections:

"Not only is it to be considered that all those diseases which are classed as septic are etiologically one and the same, and that one and the same bacterium can produce all of its forms, but we must also recognize that even the clinical pictures which they afford are capable of full and complete interpretation from the same etiological standpoint. All the manifold disease forms are simply the consequence of that variability of the different factors involved which the constantly changing relations between the invading forces of disease, on the one hand, and the resisting forces of the organism, on the other hand, occasion. Those conditions, which writers speak of as 'septic intoxication,' 'infection,' 'mycosis,' and 'pyemia,' are naught else but the results of infection, principally by one particular microbe, the *Streptococcus pyogenes*, and only occasionally by the *Staphylococcus pyogenes aureus*."

"Erysipelas, phlegmons, and carbuncles are forms of septic infection where the conflict is fought within the first system of defence of the invaded organism; in lymphangitis and lymphadenitis the conflict lies within the second system of defence; and septicemia and pyemia are evidences of conflict within the third and last means of animal defence, the blood itself."[15]

"When bacteria, possessed in a high degree of the faculty of manufacturing toxins, gain access to the organism, or when bacteria find within the tissues of their host conditions favorable to the abundant production of toxins, then the result of their invasion will be a toxemia or a septicemia; when these conditions favoring abundant production of toxins are wanting, the bacteria, provided they are nevertheless capable of maintaining and multiplying themselves, can work their noxious effects upon the organism only through the means of those proteins which are set free by the death of individuals among them, *i.e.* the proteolytic ferments; the result is a pyemia. Inasmuch, however, as in most cases toxin production and proteolytic-ferment production proceed side by side, a sharp line can never be drawn between toxemia, septicemia, and pyemia." (Sitzmann.[16])

*The Means of Eliminating the Microbes and their Toxins from the System.*—The active struggle between the invading bacteria and the defending body cells may have any one of three terminations: The active struggle may degenerate into a quasi "guerilla warfare," finding its expression in a tedious succession of smaller disease processes, the sequelæ of the

disease inaugurated by the primary infection; or the conflict may terminate in a truce, as it were, of more or less prolonged duration; or the victory of one side or of the other may be complete, and either the infected individual succumb in death, in the one case, or the bacteria be completely routed and driven forth, in the other. We will now briefly consider these three possibilities.

The condition which we have considered as analogous to a "guerilla warfare" is one in which the septic process does not actually subside entirely, but either is continued, in a more mild type, at the original site of infection, or manifests itself in constantly recurring furuncles, abscesses, or other septic processes in the same general neighborhood, or in some cases indeed at more remote points, yet in a manner to be distinguished from pyemia, both by the mildness of the processes and by their local and regionary distribution; the type of the struggle differs chiefly in degree from that of the severer forms of sepsis described in the preceding section.

The condition which we have described as analogous to a truce is one which has received careful study at the hands of many distinguished bacteriologists, notably by Halban[17] and by Perez.[18] The conclusions of Perez are quite in consonance with the careful experiments of Wauters,[19] who believes, contrary to the commonly received impression, that the bactericidal properties of the lymph glands are relatively small, as compared with those possessed by some other tissues of the body, notably by the red bone marrow. The observations of Perez are likewise in accord with those of the investigators who, with Ehrlich,[20] maintain an essential distinction between the different classes of leucocytes, distinguishing between the "myeloblasts," possessed of marked phagocytic abilities, and the "lymphoblasts," possessing this quality but in very slight degree, if at all. The observations and experiments of Perez lead him to the belief that it is the function of the lymph glands to detain the pathogenic bacteria in their meshes, and there, not annihilate them as do some of the more actively bactericidal tissues, but rather expose them to the peculiar influence of the lymphoblasts, which consists rather in robbing them of their pathogenic qualities than in compassing their entire destruction. An intermission in the conflict between invading bacteria and resisting body cells occurs when the previously active bacteria are temporarily eliminated from the tissues "at large," to be gathered into the emasculating embrace of the lymph glands, from whence, possibly, they may from time to time emerge as unruly prisoners—somewhat shorn, indeed, of their most virulent characteristics—to induce a relapse of an apparently terminated warfare, and manifest themselves often in ways totally different clinically from the first onslaught of the infection; *e.g.* what first manifested itself as a pyogenic process may, under the influence of the same bacteria, modified by their sojourn in the lymph glands, take on any of the types of non-purulent disturbance which we saw that the pyogenic germs were capable of inciting (*vide supra*), and appear as a neuralgia, as a catarrhal affection of a mucous membrane, or as a serous or serofibrinous serositis, of acute or chronic type. Thus, according to the results of the latest experimental research, do the lymph glands afford another form, quite *sui generis*, of protecting agency to the body in its conflict with infecting germs, and if unable to annihilate the invaders completely, conclude with the foe an advantageous armistice, at the close of which the body may resume the conflict under other and presumably more favorable terms.

The third and most decisive outcome of the struggle against infection is the complete destruction of the bacteria and their elimination from the system. This has likewise been long the object of closest observation and most ingenious experiment. Here again the earlier ideas of the excretion of the bacteria themselves by the emunctory organs of the body have had to give place before more recent and more exact studies, and the same is largely true of the elimination of the bacterial toxins. In regard to the elimination of the bacteria themselves, we have the authority of von Klecki,[21] corroborated by that of Cotton,[22] for the statement that though many kinds of bacteria can, indeed, be excreted by the normal bile passages in very small numbers, and probably but not certainly by the normal kidneys also—this, however, only when they are present in large numbers in the blood—yet their elimination from the body in this manner, in any considerable number, argues a lesion of the excretory organ in question. "In no wise," says Cotton most positively, "is the commonly received opinion to be accepted that the excretion of bacteria by the emunctories is to be regarded as part of the normal defence system of the body." Goldberg likewise was unable to demonstrate the excretion of tetanotoxin by the kidneys, and his experiments serve to throw doubt upon the excretion of bacterial toxins, as such, from the body by any of the excretory organs.[23] We must look then for some other way which the body possesses of ridding itself first of the microbes, and secondly of their toxins.

Thanks to the studies of Nuttall,[24] Gamaleïa,[25] Denys, Sawtschenko,[26] and Pfeiffer, we are happily in a position to offer a reasonable opinion as to the method by which the system rids itself of bacteria when it has succeeded in extinguishing their vitality. Says Nuttall in regard to the anthrax bacilli: "In the bodies of bedbugs (and of other blood-sucking insects) they become less and less capable of becoming stained with methylene blue and finally altogether so"; "they are simply digested," "*werden einfach verdaut.*" According to Gamaleïa, it may now be regarded as settled that the bactericidal substances in the body (*vide supra*, the proteolytic ferments) dissolve the bacteria. To our eyes the process becomes first appreciable as a disappearance of the staining capacity (*i.e.* a chromatolysis), in a word, a bacteriolysis. A variety of alkaloids, *e.g.* caffeine, and a variety of ptomaïnes, such as methyl- and ethylamine, have chromatolytic properties, as have a number of other bodies—among them, more particularly casein. On further investigation to determine which derivative of casein it is that occasions chromatolysis, it was found that the ammonia salt of glutaminic acid possessed this quality in marked degree. When a fluid in which chromatolysis has taken place is treated with acetic acid and filtered, and the residue on the filter paper dissolved with ammonia, we obtain bacteriolysin, which not only occasions chromatolysis, but totally disintegrates the bacteria, separates the rods of anthrax bacilli, and causes these to fall to pieces, to form but an amorphous mass of detritus. The thick, opaque emulsion of bacteria changes, under the action of this ferment, in the course of from six to twelve hours into a transparent fluid with scarcely apparent turbidity. From this last solution of bacteria the ferment can again be precipitated by means of acetic acid. The ferment which is obtained by treating anthrax bacilli with glutaminic acid has a bacteriolytic action only upon anthrax bacilli and upon no others. By the action of the casein derivative, or of an amido-acid, upon the cholera vibrio and upon the diphtheria bacillus, corresponding bacteriolysins are developed.

With these data before us, it is possible to understand fairly well how the pathogenic microbes are eliminated from the system. They are, as we have seen, actually dissolved and digested by the tissues, and it is probable that by this peptonizing action of the tissues their proteins are split up, in a manner more or less remotely analogous to the splitting up of

protein molecules in the process of gastrointestinal digestion, until they are reduced to a chemical condition which permits them to be excreted by the ordinary emunctory channels, in a form more or less indistinguishable from the products of the disintegration of protein molecules derived from any other indifferent source. It is probable that the liver is largely concerned in rendering the dissolved bacteria fit for excretion, as we know it is influential in rendering innocuous other poisonous products.

As it is only under exceptional conditions that the bacteria themselves are eliminated as such by the kidneys and the other emunctories, so likewise it is only under exceptional conditions that the bacterial toxins are eliminated as such, and in recognizable form, by the emunctory organs. On the contrary, it is recognized, in the first place, that they are in great measure neutralized by the body antitoxins before their elimination (which would in itself account for the non-appearance of specific toxins in the urine, the feces, and the sweat); and in the second place, it is more than likely that the neutralized toxins are further broken up by the action of the liver, and prepared thereby for elimination eventually by the ordinary emunctory channels in an undifferentiable form, along with the ordinary waste products of metabolism.

Having now considered in some detail first the etiology and then the pathogenesis of dissection and operation wounds, we have dealt as far as is necessary to our purpose with those characteristics of these affections which may be deemed to distinguish them from other septic processes; and it now remains for us to deal, only much less exhaustively, with the questions of their clinical course, their diagnosis, their prognosis, and their treatment, which are to all intents and purposes those of sepsis, from whatever cause arising.

Clinical Course.—The clinical course of dissection and operation wounds can best be made plain by the citation of four characteristic and illustrative cases.

Case I. That of Dr. K. Zmigrodzki of St. Petersburg.[27] The infection in this case was received from a patient who suffered primarily from facial erysipelas. The patient was dismissed from the hospital apparently well on July 7, 1888, but was received into the hospital again (August 30?) on account of an extensive phlegmon of the right scapular region. On September 5, 1888, Dr. Z. made several incisions to void the pus, and packed and drained the wound. The patient recovered quickly, and left the hospital on September 22.

In performing this operation on September 5, Dr. Z. acquired, he did not know how, a purulent infection, perhaps through some slight abrasion. Already during the night following the operation he felt severe pain in the left thumb, near the nail, on the ulnar side. On the morning of the 6th there was a developing panaritium subunguale; on the 7th he himself injected cocaine and opened the beginning abscess and applied an antiseptic dressing. He did not feel the slightest doubt of a prompt recovery, which, however, did not follow; the wound did not heal but became dry and very sensitive, and occasioned some fever. Under cocaine, a colleague removed part of the nail and made two deeper cuts, but found no pus; an antiseptic dressing was applied.

Healing was now confidently expected, but instead, on September 20, the patient suddenly had a severe chill, with pain in the left side of the chest along the margin of the rib. Thinking this to be a colitis, the patient took a dose of castor oil and calomel, but experienced no relief. A careful examination by a colleague on the 23d revealed an affection of the left lung. From the clinical phenomena there was made a diagnosis of hemorrhagic infarct, of embolic origin, which was deemed to be closely related, etiologically, to the panaritium on the left hand, as this showed not the slightest indication of healing.

Says Dr. Z., who reports the case himself, "I lay especial emphasis on the fact that there was absolutely no appearance of the advance of the inflammation beyond the distal phalanx of the thumb, neither at this time nor during the whole course of my disease; absolutely no lymphangitis, erysipelas, or lymphadenitis, the customary accompaniment of septicopyemic infections, was at any time present."

After a few days, a second infarct made its appearance, under strictly analogous circumstances, followed by a third, a fourth, a fifth, and a sixth in the course of the next three or four weeks, and all in the same left lung. The consultants called at this time confirmed the diagnosis of pyemic infarcts and offered an unfavorable prognosis, *quoad vitam*. The treatment was symptomatic, with special attention to the preservation of the general strength and the maintenance of the heart function.

At this time there developed a circumscribed phlebitis above the inner malleoli of both feet (phlebitis venarum saphenarum interiorum). This manifested itself as a livid, excessively tender swelling of the skin, which imparted to the examining finger a "doughy" feeling, if not an actual sensation of fluctuation. Under bichloride dressings this quickly subsided, leaving only some pigmentation behind.

"On October 17, the temperature, which had all along been very high, dropped from 100.4° F. to normal, and, in spite of the dubious prognosis, I began slowly to improve, my appetite returned, and on October 31, that is, on the forty-second day of my illness (counting from September 20, the day of the chill), I left my bed. After about a week and a half I went out for the first time, and my strength slowly returned. I still felt constantly dull pains in the spinous processes of the lumbar vertebræ, specially after long-continued sitting; to this, however, I paid but little attention.

"One day, on getting out of a carriage, I felt suddenly a severe pain, like a sprain, in the outer malleolus of the left foot; from that moment on pain, of a rheumatic type, persisted for a long time, extending along the whole of the left lower leg. After a couple of days there developed an evident periosteal swelling on the anterior aspect of the upper third of the left tibia, below the tuberosity, and another over the lower end of the left fibula, on the posterior aspect of the leg. I did not wish to resume my bed, and so kept about, applying hot applications from time to time.

"As I had no attacks of feverishness, I made no observations of the temperature from October 31, till November 10. On November 11, I was again obliged to resume my bed as the temperature rose with a severe rigor to 103° F., and I felt great pain in the right hypochondrium. Examination now revealed another infarct, this time in the posterior portion of the lower lobe of the right lung; this ran a course similar to that of those in the left lung, accompanied, as were they, by a remittent type of fever. But there developed in this case a fresh complication, namely, a considerable pleuritic exudate in the lower part of the right pleural cavity. The temperature excursus was very great, and was accompanied each time by rigors and profuse sweating. The pleuritic pains were at first very severe.

"In the early part of December I began to feel most torturing pains in the right hypochondrium, which I may describe as diaphragmatic, to check which I was compelled to breathe as superficially as possible, and resorted to the use of hypodermic injections of morphine. From December 1 to 15 the temperature was constantly in the neighborhood of 102° F., and the character of the fever was more or less steady (febris continua); this, of course, greatly reduced my strength. On account of steady

pain beneath the right ribs, as well as supervening painful spasms of the abdominal muscles of the right side, especially of the musculus rectus abdominis dexter, I could lie only on my right side, holding the right leg flexed at the hip. From time to time there were rigors and profuse sweating."

All these severe symptoms were scarcely explained by the comparatively unimportant anatomical changes to be found in the lungs and pleura, the only objective symptoms at that time discoverable. Repeated urinalyses failed to show any pathological change in that secretion. The condition had become very grave; all therapeutic effort seemed unavailing.

By December 20, the clinical picture became somewhat simplified, in that a swelling, apparently a perinephritic abscess, appeared in the right lumbar region. On December 21, a long lumbar incision was made, under chloroform; this revealed a purulent infiltration not only of the subcutaneous and intermuscular connective tissue, but also of that surrounding the right kidney. Fluctuation was also determined in the kidney itself. The kidney capsule was split and from it was evacuated a large amount of pus. There was present a suppurating embolic infarct of the kidney itself. The wound was irrigated and packed and treated on antiseptic principles. By evening the temperature fell to 97.4° F.; and rose the next day to 101° F.; and from the 22 to the 28 of December there was a wide variation of the temperature, evoked by the formation of a new infarct in the left lung. From December 26 to 28 the temperature fell in forty-eight hours from 104.4° F. to 97.2° F. on the apppearance of expectoration, at first bloody, but later purulent. On December 30, the temperature again rose to 101° F., but after that remained normal.

In the beginning of January, 1889, there appeared a recrudescence of the periostitic process which had been observed in October, 1888, on the upper third of the anterior aspect of the left tibia. Severe rheumatic pains asserted themselves throughout the whole of the left lower leg, and presently another swelling, similar to the one above, appeared at the old spot on the lower end of the fibula. The upper spot very quickly suppurated (in spite of vigorous mercurial inunctions) and was opened by an incision under cocaine at the end of three weeks. From the wound was removed a sequestrum of the cortical portion of the bone. On March 5, the lower swelling was opened, under chloroform, and from it also a sequestrum was removed from beneath the periosteum, which membrane was separated by a layer of pus from the underlying bone. "Both wounds healed comparatively soon, and by the end of March 1 was again out of bed."

"In spite of good diet and hygienic living my strength returned very slowly after a seven months' illness. As a sequela there developed a pronounced anemia, which was in turn the occasion of a (psychic) neurasthenia, manifested in absolute apathy, indecision, and confusion of ideas; this culminated in a "délire de persécution." May, June, and July, 1889, were passed at the seashore, where loafing, sea-bathing, and walking were helpful, along with the change of air, in restoring a certain degree of strength. Not until June did the wound in the back heal entirely.

"During my sojourn at the seashore, a new periosteal swelling formed on the lower epiphysis of the left tibia. In May, 1890, this suppurated and opened spontaneously, and after healing left a pigmented scar. During all this time the left lower leg was frequently edematous throughout. A periosteal swelling also formed on the olecranon process of the left ulna.

"Up till the present time (October 2, 1890), I suffer now and then from cramps in the abdominal muscles of the right side, and from paresthesiæ in the course of the ileohypogastric and ileoinguinal nerves."

Case II. That of Dr. Roswell Park of Buffalo, N. Y.[28] Writing under date of February 13, 1898, Dr. Park says: "For eight months, and until the first of the year, I was completely out of work as the result of an infection. Now, I am happy to report myself as well again, and hard at work. My case has puzzled every one to whom it has been submitted, and no one term or even sentence would define it all. It was certainly a mixed infection, but just when it occurred I do not know. It came on slowly with manifestations mostly confined to the lymphatics of the left arm and axilla; for two months these were troublesome. Then a sudden attack of diaphragmatic pleurisy, with probable mediastinal infection, prostrated me. Then, a few weeks later, I had the lymphatics of the arm all dissected out. I was just getting out after this when acute septic symptoms appeared, and the axillary nodes swelled enormously. I then had the axilla all cleaned out; within two hours my temperature fell 8° F. But there was no pus present either time, and cultures and all sorts of bacteriological studies gave no result. After this I went to the seashore, came back with partial (toxic) laryngeal paralysis, went abroad, was quite sick over there, but finally came home well in every respect, only wearing my scars."

Case III. That of Dr. W. W. Keen of Philadelphia, Pa.,[29] who says: "I made a postmortem on a case of suppurative peritonitis, following cancer of the stomach, at 11 A.M. In doing so, I inadvertently and very slightly pricked my right thumb with a needle. The hand was disinfected by washing, but the wound was so slight that it was not deemed necessary to lay it open at once. At six o'clock that evening I began to feel chilly, by nine o'clock I went to bed, as I felt so unwell. It was impossible for me to sleep, because by that time the thumb had become the seat of severe throbbing pain, and in the neighborhood of the prick the tissues were already becoming hard. By 2 A.M., feeling quite sure there was an infection, I called a brother surgeon who laid open the thumb and disinfected it with bichloride of mercury solution, 1 to 500, and applied the same as a dressing. A quarter of a grain of morphine gave some sleep, but by eight o'clock the next morning, about twenty-one hours after the infection, I was vomiting repeatedly, and had a temperature of 105°. Twenty-two grains of quinine and six ounces of whiskey were administered in each twenty-four hours for three days, with sufficient morphine to procure sleep. The pain was very severe. .The swelling of the thumb was so great that all the tissues were under great tension, so that it was feared that either necrosis of the last phalanx would take place, or, as a dark spot appeared on the edge of the wound, that possibly gangrene of the tissues might follow. Accordingly, on the third day, the incision already made was enlarged and the parts were disinfected anew. Fortunately the lymphatics were never involved. Within ten days the constitutional symptoms had disappeared, but the thumb did not heal for about six weeks. Two cultures were taken from the incision in my thumb (of course after the primary disinfection), but showed no growth whatsoever, though taken separately on different occasions. Unfortunately no culture was taken from the abdomen of the patient at the time of the postmortem, so that I do not know what the nature of the infection was. It seems to me that the very prompt incision made by Dr. Taylor, and the thorough disinfection account for the absence of lymphatic involvement, for I never had the slightest tenderness in the axilla; and they also account for the sterile cultures.

Case IV. That of Dr. Charles P. Strong of Boston, Mass., reported by Dr. Harrington.[30] "Dr. Strong died of acute septicemia six days after operating upon a patient with septic peritonitis, probably of appendicular origin. The nature of the disease was not de-

termined until after the death of the patient. The point of entrance of the septic poison is not known, as no wound was discovered anywhere upon the body. The circumstantial evidence is so strong that there can be no doubt that the disease resulted from the operation, notwithstanding the fact that all the usual precautions were taken.

"On the day following the operation Dr. Strong performed a hard day's work. He mentioned in the afternoon that the left arm felt somewhat sore, but he did not speak of it again in the evening. He had a somewhat restless night, and decided on the following day not to go out to his work. I saw him then for the first time. He complained of some pain in the left pectoral muscle, left shoulder, and elbow. The temperature was normal and the pulse 80. There were a loss of appetite and some nausea. In the evening the temperature was 100° and the pulse 90. The patient was drowsy through the day, and slept a good deal. There was a trace of albumin in the urine.

"On the following morning the temperature was 102°, and the pulse was 90. There was some sweating. In the evening the temperature rose to 103° and the pulse to 98. The urine contained a large amount of albumin. The patient still complained of pains in the left arm and back. There was a disinclination to take food. A moderate amount, however, both of food and stimulants was given. On the following morning the temperature remained at 103° and the pulse at 98. There was still much inclination to sleep. In the afternoon there was complaint of pain in the right knee and right thigh just above the knee. The temperature remained at 103° and the pulse rose to 108. During the night there was considerable pain in the right knee and thigh.

"In the morning there were found to be some fluid in the right knee-joint, and swelling of the lower part of the right thigh. A ham splint was put on and the leg suspended. An examination of the urine showed a large trace of albumin, hyaline, granular, and fatty casts, but no blood. The temperature had fallen to 101°, while the pulse remained at 108. The patient had been perfectly clear in his mind and fairly comfortable. In the evening the temperature had dropped to 100°, but the pulse had risen to 120 and was of bad character. The sweating became profuse. The following night was a comfortable one.

"In the morning the pulse had risen to 128 and the temperature to 101.8°. During the night the thigh had swollen considerably. The heart's action was feeble, and there was a duskiness about the skin. The respiration which had remained normal during the entire sickness rose rapidly during the morning to 50 per minute. On examination, bronchial breathing was detected over the upper lobe of the right lung. The patient sank rapidly and died in the evening, this being the fifth day of his sickness. The thigh in a few hours became dark and greatly swollen, and was covered with bullæ.

"The symptoms up to the last twenty-four hours had suggested an attack of la grippe, with the usual acute irritation of the kidneys. The condition of the right knee had suggested an acute inflammatory rheumatism. The marked changes in the thigh did not appear until the last few hours. The treatment had been supporting and stimulating. No depressants had been used. The amount of pain was not great, so that opiates were not needed. The patient did not associate his illness with the operation, which was its probable cause. It was subsequently found on investigation that, at the close of the operation, Dr. Strong had pricked one of the fingers of the left hand with a needle which was being used in closing the incision.

"Several months earlier Dr. Strong had suffered from a synovitis of the left knee, but there had been complete recovery; and no connection could be traced between this and the subsequent illness. There was no evidence of a chronic nephritis.

"*Autopsy.*—The preliminary bacteriological examination and autopsy were made by Drs. Councilman and Whitney, about twelve hours after death, and the bacteriological cultivations were made by Dr. Stone.

"There was lividity of the dependent parts of the body, and the course of the cutaneous veins was marked by dark, dirty bluish-black lines with illy defined edges. The right thigh above the knee was swollen, dark, and discolored, with numerous bullæ containing a dirty red serum. The lungs contained a large amount of frothy, reddish fluid, but there was no evident consolidation. The muscular substance of the heart and the parenchyma of the liver and kidney were very pale and opaque. The spleen was swollen, pale, and very soft. The other organs presented nothing remarkable. The muscles of the external aspect of the right thigh were dry, infiltrated with blood-coloring matter, but there was no evident pus.

"Cover-glass preparations gave the character of the bacteria as micrococci, chiefly in long chains (streptococci). Cultures were made from the heart's blood, the liver, kidney, spleen, and subcutaneous tissue of the thigh. From all of these there was obtained a pure culture of streptococci. These grew in long chains in bouillon and on agar. In the former they made the fluid cloudy for twenty-four hours, and then settled as a white precipitate. In gelatin they grew along the needle track in small isolated colonies. They grew also in milk but did not coagulate it. On blood serum the bacteria formed small white colonies, at first almost like drops of water on the surface. They developed rapidly in the thermostat at 37° C., more slowly at the ordinary temperature of the room.

"The sections of the muscles of the thigh showed that all the intermuscular spaces were distended by a mass of bacteria, there was no infiltration of leucocytes into the tissues, though the blood-vessels seemed to contain an unusually large number of white blood corpuscles. In sections of the kidney the bacteria were demonstrated with considerable difficulty, in spite of the fact that the amount of kidney substance one could pick up with a small wire loop gave over one hundred colonies when planted. When found, the cocci were in the intercellular spaces. Neither in the kidney nor in the muscular tissue was there any suggestion of arrangement of the cocci in chains. This was to be seen only when they were cultivated outside of the body.

"The case is one of true septicemia following a local streptococcus infection, the original point of infection not being evident."

Diagnosis.—The diagnosis of dissection and operation wounds is essentially that of the sepsis which accompanies them. When this has a distinct local expression, at the site of inoculation, as in Cases I. and III. the diagnosis is not specially difficult; but when the portal of infection is concealed, as in Cases II. and IV., the diagnosis presents difficulties which may even become extreme. A pure infection with pyogenic germs may, as we have seen, find expression in a great variety of morbid processes, and consequently sepsis, as a disease, may counterfeit a whole host of other more familiar morbid conditions; among others grippe, typhoid fever, malaria, rheumatism, and scarlet fever, and the specific pneumonias are those perhaps most likely to confuse the diagnosis for a time, or even till the end of a fatal case. On this account the history of recent exposure to septic infection, in a physician or a pathologist, should always be allowed weight in the diagnosis of any of these affections occurring in professional men. Two means of differentiation are available to us in doubtful cases: first, an examination of the blood for the determination of leucocytosis, and, secondly, a bacteriological examination of the blood. The first of these is quite

easy of application, and is capable of giving most important information in any case in which the system offers any considerable resistance to the invasion of the pyogenic germs.[31] The two conditions in which it may fail to afford a clew to the proper diagnosis are, first, when the infection is so slight as not to evoke any considerable reaction on the part of the tissues, and secondly, when the invasion of the system is such an overwhelming one that all the efforts to react are borne down, practically without a struggle, and the patient perishes forthwith of "septicémie foudroyante." The careful bacteriological examination of the blood is a more considerable matter, the technique of which does not properly concern us here, beyond the remark that it requires for its accurate performance quite a considerable quantity of blood (an ounce or more), and that negative results from the examination of smaller quantities should not be allowed much weight. The actual discovery of pyogenic cocci in the blood is of most grave prognostic import, and is gravest of all in the presence of streptococci. As it will be remembered that true septicemias, *strictiori sensu*, are by no means as common in man as in the lower animals inoculated with the bacteria to which they are specifically susceptible, the appearance of even a small number of germs in the circulating blood implies a most profound, extensive, and dangerous condition of general sepsis. A single word may be said in regard to the discovery, in blood specimens gathered by aspiration through the skin, of the *Staphylococcus pyogenes albus;* this coccus, which Welch has named the *Staphylococcus epidermidis albus*, has been shown by him to have its habitat in the skin in layers deeper than can be reached by any known means of disinfection. The discovery, therefore, of this germ alone in blood cultures has not the grave prognostic import which attends the appearance of the *Staphylococcus aureus* or that of the *Streptococcus pyogenes*.

Treatment.—It will be our duty in this connection to consider principally the treatment of the primary local lesion and its direct and immediate sequelæ, the treatment of the ensuing pyemia, being discussed in other parts of this work. For the formulation of a rational treatment for these forms of septic infection we are considerably indebted to E. H. Ochsner of Chicago, from whose valuable article I shall quote freely.[32]

If the infection has come from a pin prick or similar wound through a thick and calloused layer of the skin, it is advisable carefully to shave away the horny layer at the point of infection till one gets down to the quick, but one should avoid cutting into the healthy tissue. If now a little pus should form at the point, it will work its way to the surface and discharge spontaneously, or it can be released as soon as there is macroscopical evidence of pus.

If ever so slight a wound be received upon the hands during the performance of a surgical operation or of an autopsy upon a subject with puerperal fever, pyemia, septicemia, a carbuncle in its acute stage, malignant erysipelas, phlegmonous cellulitis, or suppurative peritonitis, it is worthy of the gravest consideration and of the most scrupulous care on the part of the surgeon. The suggestion of Dr. Ochsner, viz., that of shaving off the superficial epidermic layers, is very valuable, but this should be followed by active measures for disinfection. One of the most effective of these measures is the immediate application of a drop of ninety-five-per-cent. carbolic acid. If carbolic acid is not at hand, glacial acetic acid is a very valuable application, or any strong acid whatsoever; one of the best applications is the tincture of iodine; one means will always be at hand during a surgical operation, namely, the disinfectants by which the hands were disinfected in the first instance, and the resterilization of the hands with these should be resorted to without delay, the operation even being interrupted, if necessary for the purpose. If it should be absolutely necessary for the surgeon to continue the operation himself, every effort should be made to protect the tiny wound from further contamination, by the use of a finger cot, of a collodium film, or, at the very least, of a small gauze dressing.

The homely but simple recommendation to suck the wound vigorously has much to recommend it; not so much with the view, in which it was originally recommended, of "drawing out the poison," but rather because vigorous sucking occasions mechanically a certain amount of diapedesis of the blood corpuscles from the vessels, and creates artificially a chemotaxis whose default, as we have seen above, was a factor of some moment in allowing the insidious development of bacteria in cases of inoculation with but slight trauma. A more effective means of carrying out this same plan is the use of the glass suction cup of Bier, the panaritium cup, when the lesion is on the finger, or an ordinary cupping glass on parts of the body to which it can conveniently be applied.

In discussing the treatment of the kind of infections we are considering, Ochsner groups his cases under four heads:

Class I., that form of infection which betrays itself by a marked local disturbance with the formation of pus at the point of infection, the systemic disturbance being relatively slight.

Class II., that form in which there is marked local disturbance with the formation of pus at the point of infection and with an ascending cellulitis, the systemic disturbance being usually more marked than in Class I.

Class III., that variety in which there is only slight disturbance locally, but in which there is an early and severe involvement of the regional lymphatic glands and severe general disturbance.

Class IV., that form in which there is no demonstrable local disturbance and only relatively little disturbance in the regional lymph glands, but in which there is severe general intoxication due to the presence of the pathogenic bacteria or their toxins in the blood.

In the first two classes the indications are plain and the treatment is relatively simple; elevation of the extremity at the very onset, copious wet dressings; free incision and free drainage, just as soon as there is macroscopical evidence of pus. It is well in these cases carefully to apply an Esmarch constrictor to the limb, proximal to the inflamed area, before the incision is made. It is claimed that the danger of disseminating the infection is greatly reduced if this precaution is observed; the theory being that, while the incisions are being made, it is best to compress the lymphatics and veins, thus closing them until thrombi have formed in their cut ends, so as to prevent particles of infected material being taken up by either of these systems and disseminated through the body, thus furnishing foci for pyemic abscesses, septic endocarditis, or septicemia. (See also in this connection the observations of Billroth[33] on the provocation of chills in pyemia, by dressing the wound.) One other caution Ochsner emphasizes, namely this, that the incision (or incisions) should be made wholly within the infected area; that is, they should not pass beyond the line of demarcation, if such exists, as is usually the case, to a certain extent at least. By following these rules the pus can be evacuated with safety without opening up new areas to infection, and the danger from the above-mentioned complications or sequelæ is reduced to a minimum.

In considering the treatment of the third class of cases, those in which there is only slight disturbance locally, but an early and severe involvement of the regional lymph glands and quite marked systemic disturbance, Ochsner remarks that while in Europe he noticed that surgeons and pathologists differed very markedly in their treatment of this class of infections acquired during surgical operations or necropsies. Most of the surgeons seemed to favor early and free

incisions, while the pathologists had learned better. They are infected so frequently that they have learned to treat themselves much more satisfactorily than even the surgeon could. He quotes a conversation which brings out this point forcibly: One day one of the surgical assistants came to the pathological laboratory with his arm in a dressing, suffused eyes, pyrexia, and considerable systemic disturbance. The director of the laboratory, Dr. E. Fraenkel, of Hamburg, stepped up to him, asked him what had happened, and, after being told that he had an infected finger with enlargement of the lymph glands in the elbow and axilla, as well as a slight lymphangitis, said about the following: "Now do not let the surgeons get at you; go to bed, put on a copious wet dressing and you will be well in a few days, while if you let them lance it, you may be laid up for weeks; at best you will not be able to resume your work for some days if you have a gash in your finger."

The sick assistant very wisely followed the advice and was back at his work in less than a week. This he certainly could not have done with safety to himself or justice to his patients if he had an infected knife wound in his finger, as he surely would have had if he had permitted it to be lanced.

Ochsner thus briefly outlines the treatment which he has used in a large number of cases: "I insist upon rest in bed, elevation of the infected extremity, free evacuation of the bowels by means of calomel and saline cathartics, not purging, simply free evacuation, that is, three or four bowel movements the first day, plenty of good pure water, preferably presented at regular intervals so that the kidneys are able properly to perform their functions. It is quite noticeable how much better patients do in hospitals as well as in private practice if they are given a definite quantity at definite intervals. They suffer less from headache, pyrexia, and gastrointestinal disturbances. To continue, I insist further on liquid diet, avoidance of constriction to the lymphatic channels and blood-vessels, avoidance of pressure upon the lymph glands, and, finally, copious wet dressings. The dressings must be copious in order to be effective. It is in the way of putting on too small a wet dressing that many general practitioners and even surgeons often err."

The following are the theoretical reasons for believing that the conservative treatment just outlined is more rational than early free incision: The infective agent is usually introduced in minute quantities, it is virulent, and is rapidly carried to the nearest lymph glands. I am of the belief that the original point of infection soon ceases to play an important rôle in the progress of the disease. If it is just left alone, the inflammatory reaction at this point, if it has not all subsided, will do so in a very short time. The leucocytes are rapidly getting the upper hand. The conditions become entirely changed, however, if the already injured part is now subjected to a new traumatism, as a cut, for instance. Now the bacteria are again given a chance. The tissues, which are full of militant leucocytes, are killed, so to speak, by the incising knife, and they then furnish an excellent culture medium for the bacteria which may not have been destroyed; the result being a rather profusely secreting, unwholesome-looking, slowly healing ulcer.

In the fourth class of cases, those where there is practically no reaction at the point of infection, or where this may be undiscoverable; where there may or may not be involvement of the regional lymph glands, and where the general septic intoxication is severe, Ochsner recommends practically the same course of treatment as in class three just discussed.

He says, most properly, that even the most aggressive surgeons have given up incising the point of infection if there is no inflammatory reaction at all; but he opposes the practice of some who "still persist in taking out the involved lymph glands." The fortunate issue of Dr. Park's case, described above, would indicate that the removal of the affected lymph glands is in proper cases a good, it is not too much to say, the only good practice.

In this fourth class of cases, whose prognosis is always grave and often desperate, another means, not distinctly surgical, may be available for combating the bacteria which are causing the profound sepsis which threatens the life of the patient, namely, the introduction into the system of specific remedies calculated to destroy the bacteria and to neutralize their toxins. Experiment has seemed to indicate that nucleinic acid and some of its derivatives and analogues have in a measure both of these properties, that of inhibiting the development of the bacteria, and that of neutralizing their toxins.

Certain favorable reports along this line come to us in regard to the general and systemic, in distinction from the local, use of colloidal silver by inunction, in a manner similar to the use of mercurial inunctions in syphilis. In some cases of general sepsis, presumably of a streptococcic type (puerperal fever), half an ounce, or even an ounce of Credé's ointment rubbed into the flanks or the belly twice a day has appeared to influence very favorably the course of the disease. It is claimed that the hypodermic or intravenous injection of colloidal silver and of certain other colloidal metals is still more efficacious than their use by inunction. An electrolytically prepared suspension of colloidal silver, suitably packed in sterile ampoules, can be procured under the trade name of "electrargol." In some cases of septic infection it appears to the writer to have done some good.

The attempt to eliminate the bacteria themselves, or even their toxins, by means of the emunctories, as we have seen above, is very unlikely to amount to much, and powerful cathartics, diuretics, and sudorifics are more likely to prove harmful than beneficial.

Two further therapeutic resources remain at our command in combating the septic processes incident to dissection and operation wounds. Of these the first is the induction of artificial hyperemia either "active" (arterial) or "passive" (venous), according to the methods of Bier. "Active" hyperemia is that produced by heat, either from poultices or, perhaps more efficaciously, from dry hot air, or by counter-irritants, such as iodine or mustard, applied to the skin. It is, however, contended by Bier that "passive" hyperemia, through partial compression of the veins by appropriate constricting bandages, is more efficacious than "active" hyperemia in combating local septic processes in the extremities.

In cases where the local process has spread beyond the extremity proper and has already extended to the lymph nodes of the trunk, it is claimed that a "general body treatment," in which the patient's whole body, as high up as the neck, is exposed to a temperature of 300° to 350° F., is very efficacious in diminishing the severity of the symptoms.[34]

The second means alluded to is the use of biological products, derived from the action of the invading bacteria themselves, either for the induction of a "passive immunity," by means of sera taken from animals immunized against the offending bacteria, or for the induction of an "active immunity" by inoculation of cultures of the bacteria themselves, so-called "vaccine treatment." In many cases the clinical course will be so distinctly of the staphylococcic or of the streptococcic type that, even without a bacteriological examination, it will be safe to proceed with an immunizing treatment based on the clinical symptoms alone. It is much wiser, however, to determine, if possible, from smears or by cultures, the exact nature of the infecting agent before undertaking the use of sera or of vaccines.

In the case of staphylococcic infection "stock" sera or "stock" vaccines purchased in the market exhibit a fairly satisfactory potency against the septic process. In the case of streptococcic infection, how-

ever, the enormous variation in the different "strains" of these microbes demands the use of an "autogenous" product for any really reliable efficacy.

Zmigrodski, whose distressing personal experience with an operation wound has been detailed above, heads his report of his own case with a pertinent quotation from Dr. Parkes[35]; it will not be unfitting to repeat it here: "I believe these cases of severe septic infection, if they do get well, scarcely ever do so because of the doctor, but by the grace of God."

LEONARD W. BACON.


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**Distira.**—A genus of poisonous water snakes of the order Hydrophinæ. *D. semperi* is found in fresh water in the Philippine Islands. A. S. P.

**Distoma.**—A synonym for *Schistosoma* (Bilharzia), a genus of worms parasitic in the blood of man. Three species are known:—*S. hæmotobium*, *S. mansoni*, and *S. japonicum*. These worms are diecious and the male carries the female in a longitudinal slit on the ventral side of his body. The eggs are found in the urine or faeces. See *Trematoda*. A. S. P.

**Distomum.**—A generic name formerly used to include certain flukes. The genera which have supplanted this old group are *Fasciola*, *Fascioletta*, *Agaiuodistomum*, *Fasciolopsis*, *Opisthorchis*, *Clonorchis*, *metorchis*, *Paragonimus*, *Heterophyes*, and *Dicrocœlium*. See *Trematoda*. A. S. P.

**Dita.**—The bark of *Alstonia scholaris* (L.) P. Br. (fam. *Apocynaceæ*), a large tree of southeastern Asia and the adjacent islands, especially the Philippines, yielding a valuable fine-grained timber. The bark and its alkaloid have been much used at home, and to some extent in this country, as an antiperiodic substitute for quinine. It is a very rough, coarse bark, occurring in pieces as large as the hand and larger, and a fourth to a half inch or more in thickness. The outer surface is coarsely fissured and of a dark-gray or brownish color, the inner is buff and coarsely striate. The texture is largely cellular and it is easily ground or powdered. It is odorless but very bitter.

Numerous crystalline principles have been extracted from it, among them several alkaloids. *Ditaine* (or echitamine ($C_{22}H_{28}N_2O_4$) is the most important. It occurs in brightly shining, prismatic crystals, soluble in both water and alcohol. It is said to act like curare, but its use appears to have been purely experimental. Other alkaloids are *ditamine* ($C_{16}H_{19}NO_2$) and *echitenine* ($C_{20}H_{27}NO_4$). "Ditain," said to be used in the Philippines in equal doses with quinine, is a very indefinite substance. It certainly is very different from the poisonous bases noticed above.

Dita has not been found of much value as an antiperiodic; it is useful, however, as a general tonic. It appears to be a rather powerful abdominal stimulant, of value in severe diarrhea. The dose of the powdered bark is gr. iij.–viij. (0.2–0.5), or as many minims of the fluid extract.

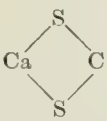
The similar bark of *A. constricta* F. von Mueller, of Australia, has there a similar repute as an antiperiodic.

HENRY H. RUSBY.

**von Dittel, Leopold.**—Born at Fulneck, Germany, on May 15, 1815. He received the degree of Doctor

of Surgery from the University of Vienna in 1840. In 1865 he was made Professor Extraordinary of Surgery in the same university. He died July 28, 1898, after a long illness.

Dittel devoted himself particularly to diseases of the bladder, prostate, and urethra; and medical science is indebted to him for several modifications in operative methods and for the invention of several new instruments. Pagel places him in the same rank, as a urologist and genito-urinary surgeon, with Sir Henry Thompson, of England, and Felix Guyon, of France. Of his numerous contributions to medical literature only the following may here be mentioned: "Beiträge zur Pathologie und Therapie der männlichen Geschlechtstheile," 1859; "Die Stricturen der Harnröhre," in the Pitha-Billroth Handbuch der Chirurgie, 1872; and "Operationen der Blasensteine," in the *Wiener medizinische Wochenschrift*, 1880. A. H. B.

**Di-thio-calcium carbonate,**  , is calcium carbonate in which two atoms of sulphur have replaced two of the oxygen atoms. It was at one time recommended as a suitable preparation in various skin lesions, probably on account of the large amount of sulphur in the molecule; but it does not seem to be much used. R. J. E. S.

**Dittany.**—American Dittany. The herb of *Cunila origanoides* (L.) Britton (fam. *Labiatæ*). This aromatic perennial, found abundantly in rich woodlands of the eastern United States, is a more energetic carminative than many of its relatives which are more frequently employed. It has a biting, peppery, aromatic taste and contains an abundance of volatile oil. This oil is distilled for the market and appears to be very similar to oil of thyme. The drug and the oil are more stimulant to the perspiratory glands than are most of the aromatics. The dose of the dried herb is gr. xv. to lx. (1.0–4.0). Henry H. Rusby.

**Diuretics** are a class of remedies which act upon the kidneys, increasing the flow of urine. Physiology has taught us that the secretion of urine is dependent upon a proper tension of the renal blood-vessels, and also upon an active state of the epithelial cells, lining the Malpighian capsule and the uriniferous tubules. Diuretic remedies form themselves into similar groups, according as they act upon the heart and circulation, causing an increased arterial tension, or, as they act upon the renal cells. They are generally distinguished as indirect and direct diuretics.

The administration of diuretics is in a great measure empirical. There is much of the function of the kidney that remains unexplained, and, of necessity, the exact action and fine differences of the various drugs is not clearly understood. The action of the indirect group upon the heart and circulation is well known, and we can depend upon their action when the blood pressure is falling, but the exact relation that this pressure bears to the secretion of urine is not yet clear. The nervous system exercises an important influence upon the function of the kidney but its relation to the therapeutic action of these drugs is not properly known. Of the direct diuretics we know that many in large doses irritate the kidney, causing strangury and hemorrhage, while in small amounts they act as beneficial stimulants, without any ill effect.

To secure proper action of diuretics, something more than simply the administration of diuretic drugs is necessary. The condition of the kidney must be fully understood, as also that of the various other organs and the general condition of the patient. The several emunctory organs act in conjunction and where one is defective the others relieve the stress by an increased and even a vicarious action. Under normal conditions the skin excretes an amount of fluid almost equal to that of the kidney, and this is augmented by that removed by the lungs, bowels, and other secreting organs. In an acutely inflamed kidney with the tubules blocked by inflammatory exudate, or with its structure partially destroyed by disease, it would not only be useless, but often harmful, to attempt to stimulate the kidney to increased action. It is more rational to relieve the blocked system by acting upon one of the compensatory organs. A free evacuation of the bowels, or a free action of the skin, will relieve the congestion of the kidney and this may be sufficient to restore its function. The excellent effect of jalap, combined with potassium bitartrate is well known, as is also the beneficial action on the kidney of a hot bath and free diaphoresis. With the relief of the acute symptoms, diuretic drugs may be given freely and with benefit, to maintain the secretion. It is also necessary to discriminate carefully in selecting the indirect or direct diuretics. If the blood pressure is low, digitalis or one of its class is indicated, but if it is above normal such diuretics are contraindicated.

The influence of a salt-free diet in lessening edema and promoting the flow of urine is a subject that has been much discussed without arriving at any definite conclusion. Although abstinence from salt does not appear to increase the flow of urine, it is evident that its free use, when the kidneys are not acting, will increase the edema when present. As salt-free diet has no injurious effect it is advisable to adopt it as an aid to other measures.

Water is probably the best diuretic we possess when the kidney is capable of acting. One to two quarts a day is followed by free flow of urine and this increase in amount is accompanied by an increase in the amount of solids excreted. It is a "flushing out" of the blood and the tissues. It is entirely unirritating and when other diuretics are administered it increases their action. There are conditions in which it must be given with care. If the kidney is not acting, it must be given gradually and the amount increased as urination increases, also, when the blood pressure is high, or, where there is edema of the tissues, it must be used sparingly or not at all. In advanced states of nephritis where the kidney tissue is destroyed to a greater or lesser extent, the function of the organ is impaired; here free urination cannot be expected and care is necessary not to overtax the enfeebled organ.

A large number of drugs have an influence in the secretion of urine, either acting directly upon the kidney or through the influence of a general stimulation. Of these experience has selected a comparative few as being of therapeutic value. The following are some of the most serviceable. Fuller details of each will be found in their special articles, throughout this Handbook.

Apocynum cannabinum is a very old remedy in the treatment of dropsy. As it is uncertain in its action and has been found to have an irritant effect upon the stomach and intestines, it has fallen into disuse. It acts upon the heart and circulation similarly to convallaria and the digitalis group. Several active principles have been separated which have a marked stimulating action upon the heart, but none is sufficiently perfected to have any therapeutic value. The fluid extract in doses of ♏ij.–v. (0.12–0.3) and the infusion, ℥ss.–i (15.0–30.0), are the most suitable preparations for its employment.

Asparagus.—This plant possesses diuretic properties, its action being directed upon the heart and circulation; it also has a direct influence upon the renal cells. It is not official in the United States or

England, but is in the French codex. It is much employed in France. Doses of fluid extract ʒi.–iv. (4.0–15.0). It is not much used but recently has been revived.

Buchu is a very old member and has the reputation of an excellent diuretic. Its properties are due to its volatile oil which acts directly upon the epithelial cells. It does not increase the amount of urine to a great extent, but has a stimulant and antiseptic effect, and increases the excretion of solids. It is more serviceable in the dropsies of kidney disease than in those due to cardiac troubles. Its best effect is secured when combined with the potassium salts and other diuretics. It is contraindicated in acute inflammatory states. The infusion is the favorite preparation, dose ʒss.–i. (15.0–30.0).

Caffeine.—This is now recognized as one of the best diuretics that we possess. Its action has been carefully investigated and it has been found to have, in addition to a stimulant effect on the circulation, a direct action on the renal epithelium, increasing the volume of urine and also its solid constituents. Its general stimulation is due to an action upon the nerve centers as well as a direct action upon the heart. When administered for any length of time, or in very full doses, its effect must be watched. It may produce irritation of the stomach, with loss of appetite and nausea, or it may show overstimulation in insomnia, nervous irritability, palpitation, and rapid pulse. Within twenty-four hours its action may be looked for.

Caffeine is insoluble and the soluble citrated caffeine is selected for use. One to five grains (0.06–0.3) may be given every four hours until the desired effect is obtained, when it should be gradually diminished.

Theobromine, an alkaloid found in kola associated with caffeine, has been suggested as a substitute for the latter. It was thought to be less irritating and more actively diuretic. It has failed to replace the better known drug, and has not proved to be more satisfactory. It is insoluble and is administered as the sodio-salicylate, a double salt which is soluble in half its weight of water and has been sold under the trade name of *Diuretin*. It is much weaker than caffeine and is given in ten- to fifteen-grain doses (0.6–1.0). It has been found to have the same objections as caffeine, proving irritating to the stomach and having an equally disagreeable taste.

Theocine is a synthetically formed alkaloid, which in nature occurs with caffeine in the tea plant. It has been suggested as an exceptionally active diuretic. Dose, gr. iij.–v. (0.2–0.3). It also possesses an unpleasant taste and disturbs the stomach. Its actual value as a diuretic is as yet uncertain.

Digitalis.—This is the best known and remains the most satisfactory of the indirect diuretics. It acts upon the musculature of the heart, improving the force of the systole and increasing the tension of the blood-vessels. Its action is evident in from one to three days, and in suitable cases, it increases the flow of urine in a most marked manner. It is most serviceable when the deficient action of the kidney is due to valvular disease of the heart and weakening compensation. It requires to be given with some caution, particularly when the cardiac walls are dilated and enfeebled. When administration is continued for a prolonged period it will irritate the stomach, producing nausea. As its effect in slowing and strengthening the heart becomes manifest, the dose should be lessened, and it may be discontinued at intervals, or alternated with convallaria or other member of the digitalis group, with advantage. It should not be given except with great care where there is an increased blood pressure.

The infusion and tincture are selected for use—the former being preferred as a diuretic, in doses of two to four drams. The action of digitalis is increased when combined with other diuretics such as the spirit of nitrous ether, or any nitrite, which dilates the peripheral vessels, also with the saline and other direct diuretics, to assist their action upon the renal cells.

Strophanthus, convallaria and several allied drugs have an action almost identical with digitalis. As heart tonics they may replace or alternate with it, but as diuretics they have not the same diuretic action as the older drug.

Spirit of nitrous ether is a stimulating diuretic of great value. It acts directly upon the kidney epithelium and also dilates the renal vessels, allowing an increased flow of blood. It is a very popular remedy, either when administered alone or in combination with other diuretics. The dose is ʒss.–i. (2.0–4.0) every two hours. If the preparation is good it may be given freely without any ill effect. The one difficulty encountered is the inferior quality of the preparation ordinarily obtained. It rapidly deteriorates when exposed to the air or light, losing its therapeutic properties and becoming an irritant to the stomach and nervous system.

Fabiana (*Pichi*).—This is one of the newer aromatic diuretics, resembling juniper and buchu, acting directly upon the renal epithelial cells. It augments the amount of fluid but slightly and is soothing and disinfectant. Its properties are due to its aromatic oils and resins. The dose of the fluid extract is ʒss.–i. (2.0–4.0).

Juniper.—This is a well-recognized diuretic, whose properties are due to its aromatic oils. It resembles buchu and is employed in chronic disturbances of the kidney. Formerly it was much used but other drugs have replaced it. The diuretic effect of gin is due to its presence. The *compound spirit of juniper* of the U. S. National Formulary has been prepared as an official substitute, dose ʒi.–iv. (4.0–15.0). *Spirit of juniper* is given in dose of ʒss.–i. (2.0–4.0).

Salines.—The salts of potassium rank with the best diuretics we possess. They act directly upon the renal epithelium throughout its course, producing a free flow of urine and increasing its solid constituents. They are unirritating and may be used wherever diuretics are indicated. The acetate, citrate, and bitartrate are all used in five- to twenty-five-grain doses. The nitrate is equally useful in two- to five-grain doses. The bitartrate and nitrate differ from the other salts in producing an acid urine which may prove irritating to the kidneys and bladder if continued for a prolonged period. They exercise their beneficial effects when given freely diluted with water, and when combined with digitalis, or the balsamic remedies.

Scilla resembles digitalis in its action. In addition it acts directly upon the kidney, and in excessive doses it acts as an irritant to the urinary tract producing strangury and bloody urine. It is now rarely used except in combination as in the well-known pill of squill, digitalis, and blue mass, or the Niemeyer pill of squill, digitalis, and calomel. The dose of the powder is gr. i.–v. (0.06–0.3).

Scoparius is an old and useful diuretic which had fallen into disuse, being replaced by its active principles *sparteine* and *scoparin* upon which its action depends. Scoparin and sparteine have been investigated closely as to their action, with the result that sparteine, which for a time almost supplanted the crude drug, is now being put aside as its diuretic property is found to be very slight. Scoparin is unstable and cannot be given separately. The decoction which represents all the principles is now being favored. Half an ounce to one pint of water, boiled to half a pint, is given in one-ounce doses. The dose of sparteine is one-half grain gradually increased.

Scoparius, in addition to an action upon the heart resembling that of digitalis, exerts a direct action upon the renal epithelium, which makes it a valuable diuretic. The uncertainty of scoparius is probably due to the improper preparation and preservation of the fresh drug.

Uva ursi acts directly upon the urinary epithelium, resembling buchu, but is more sedative and causes a greater flow of urine. It is given as the fluid extract in dose of ʒss.–ij. (2.0–8.0) or as the infusion, dose ʒi.–ij. (30.0–60.0). It is rarely employed.

Beaumont Small.

**Diuretin.**—The trade name of a compound of sodium theobromine and sodium salicylate. It was introduced by Dr. Christian Gram of Copenhagen, who originated this method of producing a soluble salt of theobromine. Its action is that of theobromine (*q.v.*). Beaumont Small.

**Dochmius.**—A generic name formerly used to include certain species of parasitic round worms. The generic names *Agchylostoma* (*Ankylostoma*) and *Necator* are now used. These are the hook-worms and their relatives. See *Nematoda*.

**Dock.**—See *Rumex*.

**Dogwood, Flowering.**—See *Cornus*.

**Dogwood, Jamaica.**—See *Piscidia*.

**Dogwood, Poison.**—See *Rhus* under *Poisonous Plants*.

**Dolomol** is a name given to magnesium stearate or to various mixtures of magnesium or calcium stearate and palmitate. It is used as a dusting powder, mainly in dermatological and surgical practice; and is often combined with acetanilide or ichthyol.

R. J. E. S.

**Donders, Frans Cornelis.**—Born at Tilburg, Holland, on May 27, 1818. From 1835 to 1840 he studied medicine at the University of Utrecht. He afterward received the degree of Doctor of Medicine from the University of Leyden. In 1848 he was made an extraordinary professor at the University of Utrecht. It was not, however, until 1852 that he devoted himself more particularly to ophthalmology. During the following ten years (1852–1862) he carried on an ophthalmological practice, in addition to much scientific work, but after that time he devoted himself exclusively to subjects belonging to the broad domain of physiology. From 1863 to 1888 he occupied the regular chair of this branch of medical knowledge in the University of Utrecht, as successor to Schroeder Van der Kolk, and he rapidly rose to be one of the greatest authorities in the world in this as yet only partially explored domain. At the same time it is probably true that the greater part of his reputation was due to the remarkable researches which he made in those departments of ophthalmology which have to do with refraction, accommodation, the determination of the proper kind of glasses required for special conditions of the eye, etc. Donders was also greatly appreciated for his gift of communicating knowledge; he was an admirable teacher. He died at Utrecht, March 24, 1889.

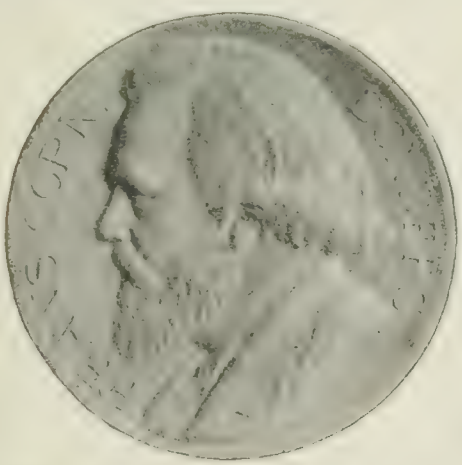


Fig. 1785.—Frans Cornelis Donders. From the Donders medal by Pier Pander, made for the IX. International Congress of Physiology at Groningen, Sept. 2–6, 1913.

Of his numerous contributions to medical literature the following deserve to be specially mentioned: "Zur Pathogenie des Schielens," *Archiv für Ophthalmologie*, 1863; "Ueber einen Spannungsmesser des Auges" (Ophthalmotonometer), *Arch. f. Ophth.*, 1863; "The Anomalies of Refraction and Accommodation," issued by the New Sydenham Society, 1864; "De l'action des mydriatiques et des myotiques," *Annales d'oculistique*, I., III.; "Klangfarbe der Vocale," *Arch. f. die Holländ. Beiträge*, 1864; and "Die Schnelligkeit psychischer Processe," Reichert's and Du Bois-Reymond's Archiv, 1868. A. H. B.

**Dormiol.**—See *Amylene Chloral*.

**Dorsey, John Syng.**—Born in Philadelphia, Pa., December 23, 1783. He commenced the study of medicine at the early age of fifteen, and was graduated at the University of Pennsylvania in 1802. One year later he visited France and England, and then returned to Philadelphia. In 1807 he was chosen adjunct to his uncle, Dr. Physick, in the chair of surgery, University of Pennsylvania. In 1813 he published his "Elements of Surgery," a work which was adopted as a text-book in the University of Edinburgh. During his service as surgeon to the Pennsylvania Hospital he tied the internal iliac artery, the first time the operation was performed in this country. In 1818, upon the death of Dr. Wistar, Dr. Dorsey was made Professor of Anatomy. Unfortunately, the opening lecture of the course was the only one he was able to deliver, as death (from typhus fever) overtook him ten days later (November 12, 1818).

The personal popularity of Dorsey was very great. Dr. Chapman, who knew him well and intimately, said, among other things, that "his warmth of manner, his kind and genial disposition, his enthusiasm, the charm which he threw around his subject, his well-known honesty and the uncommon interest which he evinced in the instruction of his pupils, all conspired to render him the idol of his classes, both public and private." Stone, in his "Biography of Eminent American Physicians and Surgeons," says that "Dorsey was a brilliant operator, and an honest, conscientious surgeon and medical practitioner, doing nothing merely for the sake of doing it, but always for a definite object.

**Dosage.**—Under this title will be discussed the principles that determine standard dosage, and the circumstances that necessitate modification of such dosage.

1. Standard Dosage.—The word *dose*, in connection with the matter of the administration of medicines, is used in two distinct senses, which must be carefully discriminated, as follows: In one sense the dose of a medicine may be taken to mean the quantity necessary

to produce a certain therapeutic effect for the time being, and in another acceptation the same word signifies the quantity to be administered in a single portion. Very frequently the two doses, in these two senses, are identical—the quantity necessary for an effect being given all at once—but very often again they are not. Thus gr. xx. of quinine—a *dose* of that medicine for an antipyretic effect—may be *administered* in four individual *doses* of gr. v. each, taken at short intervals.

Dose, in the sense of quantity necessary for a given effect, is, of course, determined by trial. In stating doses in this sense, the point must be regarded whether the effect sought is to be a passing one only or a continuous one. In the former case the dose can categorically be stated, as, for instance, that the purgative dose of castor oil is a tablespoonful; but in the instance of a continuous effect such categorical statement is impossible, since dose now refers to the quantity necessary to be present in the blood at any single moment. Dose, in such case, must be stated in terms of the amount required to be given within a certain period for the maintenance of the necessary impregnation of the system. In such statement the period most convenient, and therefore most commonly used, is the term of twenty-four hours. So, for instance, we say that the dose of a bromide as a single sleeping draught is simply so much; but we state the dose of the same medicine for the controlling of epilepsy at *so much a day*, since now a certain grade of bromism must be maintained unremittingly for long periods of time.

Standard dosage never can be set at a precise figure; in the first place, because therapeutic achievements do not permit of precise mensuration, and, secondly, because the factors that determine degree of medicinal effect are many and impossible of exact estimate. All posological tables, therefore, must be taken to exhibit only averages. Individual medicines may have more than one standard dosage if they subserve different purposes attained by different dosage. Thus quinine has one dose as a simple bitter stomachic, but another and quite different one as an antipyretic.

Dose, in the sense of *amount to be administered in one portion*, is, of course, based primarily on dose in the foregoing sense, but is also affected by other considerations. In cases in which a transient effect only is wanted, the rule is to give the whole dose at once, unless there be positive disadvantage in so doing; and that practically means unless the whole dose, swallowed in single portion, would be likely to disorder the stomach. In such case the charge is given, as the phrase is, in *divided doses;* that is, in portions administered in even succession at intervals long enough to save the stomach, but short enough to secure the practical presence of the whole charge in the blood at once.

In cases in which the medicinal impression is to be continuous, the daily allowance is to be given in such division of dosage as will best harmonize the conflicting considerations of maintaining an equable impression on the one hand, and avoiding an undue disturbance of the patient on the other. For the one consideration calls for administration by frequent small quantities, and the other, on the contrary, for the minimum of frequency. Practically, the rule is to dose no oftener than necessary for the maintaining of a fairly equable impression, and to reduce this frequency still further if it disturbs the patient, or his stomach, unduly. The amount of each dose will be determined by the frequency. In following out this rule, the first thing to find with a given medicine is that minimum of frequency of giving which will attain a practical equability of effect. This minimum will differ enormously with different drugs—a fact often not properly recognized—being determined by the relation between rate of absorption and elimination, a rate which varies greatly among medicines. In a general way, compounds of the heavy metals are slow of elimination, whence follows the fact that a mercurial impression is practically equable with a renewal of doses, by the mouth, of no greater frequency than thrice daily, or, by inunction or fumigation, once daily; and, similarly, that tonic doses of iron hardly require more frequent giving than three times a day. Salts of the alkalies of high diffusion power, however, are much more rapidly eliminated; so that to maintain an equable effect with them the daily allowance, in continuous medication, should be broken up into four charges at least, and a distribution into six may in many cases be distinctly advantageous. The alkaline iodides and bromides are prominent examples of this class of medicines, and the best therapeutic effects of these salts are often missed through the error of giving at too long intervals. Diffusible alcohols and ethers must be given more frequently still, if the effect is to be maintained with any approach to equability, and the same is true also of many neurotic alkaloids. A prominent example in point among alkaloids is aconite, which, given for the purpose of reducing heart action, should be administered at least hourly, the amount given on each occasion, of course, bearing proper relation to the frequency.

The second consideration is so to grade the frequency that the individual doses will be small enough not to derange the stomach, or to produce constitutionally an initial overgreat effect. Here again the importance of the consideration is often overlooked by prescribers, and a patient is unnecessarily sickened, or his functions are unduly disturbed, by large infrequent dosage, when precisely the same therapeutic effect from the medicine could have been obtained without distress or without derangement by the same dosage broken up into more frequent, and hence smaller, individual charges.

But while there is, thus, an advantage in dosing, for continuous impression, by the method of "little and often," yet the consideration of the disturbing of the patient forbids the carrying of the method to extremes. This consideration is serious in cases of slight indisposition on the one hand, and of desperate illness on the other. In the one case the patient, not too sick to attend to his ordinary avocations, is intolerably annoyed by an overfrequent dosing, and in the other the subject, ill nearly unto death, and needing the most careful nursing of his fast-ebbing vitality, is likely to have his life literally worried out of him by incessant wakings and liftings to swallow medicine.

An important factor affecting standard dosage—whether dose for a transient or a continuous effect—is the *bulk* of the subject, since obviously, for constitutional effect of constant degree, the amount of drug must be proportioned to the amount of blood in which the drug is to be dissolved. This consideration obtains especially in prescribing for children. To meet the case of the necessary scaling of doses to fit the varying bulks of this class of patients, several formulæ have been devised, of which the two in commonest use—Young's and Cowling's—work by the *age* of the subject, on the presumption—true enough for the purpose in hand—that children of a given age are of a given bulk. Young's rule is that, taking the adult dose at unity, the fraction thereof proper for a child of given age is expressed by the formula $\frac{\text{age}}{\text{age}+12}$. At age six, for instance, the fraction is $\frac{6}{6+12}=\frac{6}{18}=\frac{1}{3}$, *i.e.* a child six years old should be given one-third of the dose proper for an adult. Cowling's formula is, under the same premises $\frac{\text{age at next birthday}}{24}$. At age six, by this formula, the proper fraction of the adult dose is $\frac{7}{24}$ = a little less than $\frac{1}{3}$. In general, with the younger ages, Cowling's formula yields a slightly smaller dosage than Young's. A formula much less used, because of its

inconvenience, is Clarke's, wherein actual weight, instead of age, determines the dose. In this formula, standard dose being unity, the dose for a subject of given weight is expressed by a fraction of which the numerator is the number corresponding to the weight in avoirdupois pounds, and the denominator is the arbitrary number 150, supposed to be the weight, in pounds, of the average human adult.

2. Circumstances Necessitating Modification of Standard Dosage.—These circumstances, which are many and potent, are as follows: *Age*, apart from the consideration of bulk of subject, calls for special adjustment of dose in the case of many medicines. In general, children are more susceptible to drug influence than adults, and this fact obtains strikingly in the instance of opium. In general, furthermore, both extremes of age bear actively perturbing medication badly. *Sex* is another element to be considered in adjusting dosage—women, bulk for bulk, being generally more susceptible to medicines than men, and particularly so as regards neurotic drugs. *Climate* also must be regarded, with especial reference to the fact that in warm weather the digestive system is unduly sensitive, and the system generally more susceptible to depressing influences. *Custom* may affect dosage powerfully, sometimes by enhancing, but more commonly by lessening, normal effects. This lessening is seen markedly in the case of the strictly neurotic effects of so-called neurotic drugs, such as opium or alcohol, although with this same class of drugs—a fact often overlooked—the effects *other* than neurotic may be wholly uninfluenced, or even enhanced in intensity, by habit. Thus, for instance, appears the curious anomaly in the case of the confirmed toper that with ever-increasing indulgence he gets not any more drunk than before, in the commonly understood sense of the word, but yet does get progressively more and more catarrhal as to his stomach and bowel, more cirrhotic as to his liver, more apoplectic as to his brain, and more debased as to his memory, manners, and morals, with every drop added to his daily allowance of liquor. *Idiosyncrasy* is another important factor in dosage, working now to increase, and now to lessen, the standard; and, lastly, *physiological status* must be regarded, since, in practice, morbid conditions may modify profoundly normal susceptibility to medicinal influences. A notable instance of this circumstance is, once more, in the case of neurotic drugs, which, in conditions of great devitalization, require very much larger doses than normal to produce normal grades of effect. Thus a subject at death's door from a sudden voluminous loss of blood may swallow doses of opium or of brandy that would actually be fatal in health, but now with no other effect than to sustain the failing heart and nervous system until natural recuperation begins. *Method of administration* of a drug is an important factor in the question of dosage. Thus drugs given by hypodermic injection should be about two-thirds or three-fourths of the dosage of the same drug administered *per os*. In drugs administered *per rectum*, the dose may be increased one-fourth. In actual prescribing, therefore, particularly of neurotic drugs, the wise physician regards posological tables as furnishing points of departure, only, for the increase or diminution of standard dosage according to the condition of the patient.

From all the foregoing two corollaries appear, of obvious practical importance—the one that dosage for a given drug cannot be set at one categorical figure; and the other that, even with given conditions, dosage never can be estimated with any approach to precision.

Edward Curtis.
R. J. E. Scott.

**Douglas, James.**—Celebrated anatomist, first physician of the Queen of England, and member of the College of Physicians of London and also of the Royal Society of that city. He was born in Scotland in 1675. After he had received his doctor's degree he established himself in London as an accoucheur. At the same time he gave instruction in anatomy and published a large number of treatises on a great variety of topics. He died at London in 1742.

Of his published writings that which contains an account of his dissection of that part of the peritoneal cavity which is now known as "Douglas's cul-de-sac," is the only one which we shall mention here. Its title reads: "A description of the peritonæum, and of that part of the membrana cellularis which lies on its outside, with an account, etc.," London, 1730.

A. H. B.

**Dourine.**—(*Maladie du coït*—covering disease). The disease of horses caused by an invasion of *Trypanosoma equiperdum*. It is characterized by specific lesions of the male and female genital organs and of the lymphatic and central nervous systems.

The disease has long been endemic in Arabia and parts of Continental Europe, and has been carried recently to the northwestern United States, appearing in Montana, Nebraska, Iowa, Illinois, the Dakotas, and in Canada.

As already stated, the disease is a trypanosome infection. This was observed by Rouget in 1894. Doflein in 1901 described and named the parasite *Trypanosoma equiperdum*. The infection is communicated directly in sexual intercourse, and in its pathology and clinical course the disease bears a considerable resemblance to human syphilis.

In from ten to twenty days after coitus, sometimes longer in the stallion, there begins (1) *the stage of edema*, with irritation, redness, swelling of the genitalia. This is followed in from forty to sixty days, by (2) *the stage of eruption*, characterized by fever, lymphatic induration, and synovial swellings; and by circular edematous swellings as large as a half-dollar, pitting on pressure, and appearing especially about the flanks, hindquarters, and thighs. These are transitory, appearing and disappearing. The animal is greatly weakened and passes finally into (3) *the stage of anemia and paralysis*. In this stage, and in severe cases during the second stage, ulcers and abscesses form upon and around the genitalia, tail, and thighs. The pregnant mare aborts. The animal is reduced to a wretched condition of emaciation, lameness, debility, and paralysis, and dies in from four months to two years from the onset of the disease.

Post mortem there is infiltration and exudation throughout the lymphatic and central nervous systems.

The disease is spread only by coition. Diseased animals should be prevented from coming in contact with healthy ones in this or any other way; infected animals should be destroyed; stables, utensils, and clothing used for the sick horse should be thoroughly cleaned and disinfected. Attempts have been made to treat slowly developing cases with intravenous injections of atoxyl, but without much success.

J. F. Leys.

**Dover, Thomas.**—Born at Barton-on-the-Heath, Warwickshire, England, in 1660. During his youth he lived for a certain length of time in the house of Sydenham, the famous physician, and while residing here he passed through an attack of smallpox. This experience is thus described by A. C. Wootton, in his "Chronicles of Pharmacy": "First he was bled [by Sydenham] to the extent of twenty-two ounces; then he took an emetic. He only took to his bed when he became blind with the disease. In his bedroom he had no fire, the windows were always kept open, and the bedclothes were only allowed up to his waist. This

was in the middle of January. For medicine, Dover says, 'he made me take twelve bottles of small beer acidulated with spirit of vitriol every twenty-four hours,' and, he concludes, 'I never lost my senses one moment.'"

During his early manhood and the middle period of his life Dover appears to have led a life of adventure, both on sea and on land. He is believed to have died about the year 1742, after practising his profession, during the last twenty years of his life, in the city of London. His formula for "diaphoretic powder" (which has been known since 1788 as "Dover's powder") is stated by Wootton to be as follows: "Take opium one ounce; saltpeter and tartar vitriolated, each four ounces; liquorish one ounce; ipecacuanha, one ounce. Put the saltpeter and tartar into a red-hot mortar, stirring till they have done flaming. Then powder them very fine. After that, slice in your opium; grind these to a powder, and then mix the other powders with them. Dose [in a painful attack of gout], from forty to sixty or seventy grains in a glass of white wine posset going to bed, covering up warm, and drinking a quart or three pints of the posset while sweating. In two or three hours at furtherest the patient will be free from pain, and though before not able to put his foot to the ground, 'tis very much if he cannot walk next day. The remedy may be taken once a week or once a month." A. H. B.

**Dracunculus.**—A generic name formerly applied to certain species of the modern genus *Filaria*. These animals are parasitic roundworms. See *Nematoda*.
A. S. P.

**Dragon's Blood.**—Resina Draconis (*Sang dragon*, Codex Med.). A deep-red resin which exudes spontaneously from the ripe fruits of *Calamus Draco* Willd. and from other species of the genus (fam. *Palmaceæ*), rattan palms of Borneo, Java, and other Polynesian islands. It is collected by shaking the ripe fruits in a basket, sifting out the resin and, by means of warmth, moulding it into little balls, or more usually into slender sticks, twenty or thirty centimeters long and about as thick as the finger. These are wrapped in pieces of leaves and tied. Inferior qualities are made by boiling out the resin from the fruits, and hardening it in masses. Large, brilliant red cakes should be looked upon with suspicion, as they are apt to be thus boiled, and also often heavily adulterated.

Dragon's blood is in mass a brown-black, brittle resin, of no odor, and of a sweetish, afterward slightly acrid taste. It breaks with a reddish fracture, and is translucent in thin layers. It is entirely soluble in alcohol, chloroform, carbon disulphide, etc., with the exception of from ten per cent. upward of vegetable tissue and other impurities. It softens and becomes sticky by the warmth of the hand, and at a higher temperature is partly decomposed, liberating among other things benzoic acid, and giving off the odor of benzoin.

It is extensively used in coloring wood, stains, and for chemical manufacturing, varnishes, etc., but has no peculiar medical properties. Its only use in pharmacy is as a harmless coloring matter for tooth powders, ointments, and similar pharmaceutical mixtures.
H. H. Rusby.

**Drake, Daniel.**—Born in Plainfield, N. J., October 20, 1785. His early youth was spent in Kentucky. In the autumn of 1800, at the close of his fifteenth year, he was sent to Cincinnati, Ohio, to fit himself for the medical profession. "The arrangement was that he should live in his preceptor's family, and that he should remain with him four years, at the end of which he was to be transmuted into a doctor." (Stone.) In 1805 he went to Philadelphia and attended his first course of lectures in the University of Pennsylvania under Rush, Wistar, Barton, Physick, and Woodhouse. He finally settled in Cincinnati. In 1815 he attended his second course of lectures in the University of Pennsylvania, and at the end of this course he received the degree of Doctor of Medicine. In 1819 Dr. Drake founded, at Cincinnati, the Medical College of Ohio; he himself taking the chair of medicine. Dissensions soon arose and Drake was obliged to give up his position. In the summer of 1835, after he had held, for brief periods, professorships in other institutions, he conceived the project of organizing the medical department of the Cincinnati College. During the brief existence (four years) of this new medical school several men who afterward became eminent as teachers and practitioners, were members of its Faculty. Among the number may be mentioned: James B. Rogers, Professor of Chemistry in the University of Pennsylvania; Horatio G. Jameson, a distinguished surgeon of Baltimore; Samuel D. Gross, of Philadelphia; and Willard Parker, of New York. Drake's death occurred November 6, 1852.

Drake was a prolific writer. His contributions to current medical literature would, it is estimated, fill several large octavo volumes. He was also the founder, in 1829, of the *Western Journal of Medical and Physical Sciences*. In 1832 he published a voluminous work entitled: "A Practical Treatise on the History, Prevention, and Treatment of Epidemic Cholera." Finally, in 1850, he published the first volume of his greatest work, viz., "A Systematic Treatise on the Principal Diseases of the Interior Valley of North America, as they appear in the Caucasian, African, Indian and Esquimau Varieties of its Population." The second volume was published some time after his death. A. H. B.

**Draper, John William.**—Born at St. Helen's, near Liverpool, England, on May 5, 1811. After studying chemistry under Dr. Turner, at that time the most celebrated of English chemists, he came to America and completed his medical education at the University of Pennsylvania, being graduated in 1836. Soon afterward he was appointed Professor of Chemistry in Hampden Sydney College, Virginia, and in 1839 he received an appointment to the same professorship in the University of New York. In 1841, when the University established a Medical Department, Dr. Draper was transferred to it, first as Professor of Chemistry, and then afterward as Professor of Physiology and Chemistry. In 1856 he published "A Treatise on Human Physiology, Statical and Dynamical," and this work became a standard textbook in American colleges. From this period onward, Dr. Draper's career partook largely of the character of an historical and philosophical writer. Two of his published writings obtained a world-wide celebrity —viz., "History of the American Civil War," and "History of the Conflict of Religion and Science." Dr. Draper died Jan. 4, 1882. A. H. B.

**Dreams.**—We think in one of two quite different ways: first by the method with which we are all familiar and to which the term thinking is almost exclusively applied. In this method of thinking there is clear consciousness in the sense that the person is definitely oriented toward reality and the thinking is carried on with the exercise of careful critique and under the control of the processes which we term intellectual. Such clear conscious intelligent thinking has its motivating incentives in reality.

There is another kind of thinking, however, which is very different from that just described. It is the

thinking which takes place without conscious direction or critique, the thinking in which ideas follow one another without selection, coming and going without apparent reason, and corresponding, not at all, with any relation between the individual and reality. This is the kind of thinking that takes place during dreaming, either during the dream of sleep or during day dreaming, at times of mental abstraction and so-called wool gathering, and the thoughts which come at such times we no longer call thoughts, but phantasies.

What is the significance of this thinking by phantasy formation? To understand this we must stop for the moment to realize that the general function of mental life is to bring the individual into effectual adaptation with his environment and that if we will glance for a moment over the life of the individual from the period of the first few weeks, when the principal motive in life is nutritional, to the time of adulthood with all its conflicts and social demands, we will realize that in the process of adjustment which has necessarily taken place in the interval there has of necessity had to be put aside, more and more, as the demands from the outside increased, the immediate satisfaction of the demands which clamor for recognition from within. And so the process of adaptation has of necessity to have been one of compromise, compromise between the pleasure motive which would demand the immediate satisfaction of all bodily cravings and the reality motive which puts off fulfillment into an ever receding future of the demands of the present and insistent world of reality.

The world of phantasy therefore, the world of dreams, is dominated not by the reality motive, but by the pleasure motive, and it is for this reason that phantasy formations, whether they occur in the sleeping or in the waking state and whether they be termed dreams or visions or what not, are fundamentally wish-fulfilling. We therefore see at the outset a certain fundamental conflict at the very root of the personality, and realizing the nature of this conflict we should not be surprised when we find an individual unable to measure up to the demands of the real world, sinking back into his own world, the world of phantasy, the world where things come true as he would wish them, escaping from the demands of real life, and taking flight into this region either in his dreams or perhaps in a psychosis.

When we further realize that the conscious mental life of the individual is by far the smallest part of that mental life, that practically all of the things that control his thoughts and actions, all of that complex mass of material that goes to make up the individual as we know him, to formulate his personality, that gives the peculiarities that distinguish him from others, all this mass of material lies out of the range of clear conscious awareness and in the region from which come the phantasy-forming impulses, then we begin to realize the tremendous importance of these phantasies for the understanding of the individual. They are representatives of by far the greater portion of the mental life and they are the representatives of the true desires of the individual. If we can fathom their meaning then we can plunge at once into the very heart and core of the true personality.

Very little of our lives is controlled by what we are pleased to call the intellect. The motivating factors both of thought and action are fundamentally emotional in character and not only that, but they are the emotions that represent the feelings that have been builded up during our whole lives and which lie for the most part beneath the surface; and although we very frequently flatter ourselves that we are proceeding quite contrary to our own desires, in the teeth, so to speak, of their opposition, being controlled by reason, still a deeper analysis of the situation may show the absolute contrary. Dr. Hall has suggested a most valuable illustration: Originally the course of icebergs was supposed to be controlled by the wind, but how can the course of icebergs that proceeded in a direction against the wind be explained? Such anomalous phenomena received their explanation only when it was realized that nine-tenths of the iceberg was submerged and that this greater nine-tenths, subjected to all of the deflecting forces of the ocean currents, might very well carry the exposed one-tenth against the wind. Thus it was seen that the course of the iceberg was not a matter of aerodynamics so much as of ocean currents. So it is with the human mind. The course which the individual takes is rarely ever more than apparently controlled by reason. The rationalizations in which he indulges as explanatory of his conduct may be satisfying to him, but to the psychologist are often unconvincing.

From this introduction, therefore, it would seem to be a perfectly plain conclusion that if we can read the meanings of the phantasies we can at once come into touch with the real human being; that in the interpretation of phantasies, of which dreams are only one variety, we are in the presence of the open door to the soul. The dream never deals with trivialities; the dream phantasy always has to do with something that is close to the heart of the dreamer. No dream is therefore unimportant for the understanding of the individual and every dream furnishes leading strings to the core of the personality.

Not long ago when I was visiting a hospital I came into the examination room where I found some physicians engaged in examining a patient. He was suffering from a marked tremor and no examination to which they had subjected him appeared to be at all satisfactory in the results which it gave. It did not appear that he presented any objective symptomatology that enabled them to come to any conclusion as to the possibility of an organic lesion or its location. The case apparently was a functional one and yet no questions were able to elicit any information of importance. The man was a densely ignorant Irish laborer who had never used his mind, who was more accustomed to the use of the pick and the shovel, and questions of any sort elicited monosyllabic responses that gave no information. How should one proceed in such a case to find out about the individual? One might ask any one of thousands of questions, pursue any one of thousands of roads, trusting that one of them might lead somewhere. How shall we get the really vital fact with which to start? The answer is through the dreams. I succeeded after a few questions in finding out that this man had had a dream, I believe the night before. The only thing, however, that he could tell me about the dream was that he had dreamt of his cousin. So we have one fact added to all the facts which the other physicians had obtained in hours of examination, the fact of his cousin, and yet from the principles which I have above stated I knew that that was a vital fact in his life, that was a point from which we could gain some access to his personality. It was true, for in twenty minutes I had all of the high lights of his life laid before me: the story of his life in Ireland, his immigration to this country, his marriage and life with a drunken wife, and so on. All came out with comparative ease simply because I had something to start with, and this is an illustration of how the dream, even when it is apparently so incomplete as in this case, may be an open door through which one can enter the personality of the patient.

The dream always uses as the material through which it expresses its meaning the experiences of the last waking state and it is because of this fact that so many psychologists have insisted and still insist that the dream is the result of sensory experiences and can be modified by sensory stimuli more or less at will, as for example, a man kicks the bed clothes off at night and dreams of being in the Arctic regions, and such like examples. This is an example of the famil-

iar fallacy of post hoc ergo propter hoc. The reason why the dream uses the material of the last waking state is perfectly plain. Something in the previous waking period by associational relationship has touched an important complex in the individual, stirred it into activity, which activity is expressed in the phantasy formation of the dream of that night. The process may be compared to the vibration of the A string on the piano. If one holds a vibrating A tuning fork over the harp it is the A string and only the A string which vibrates, not the G nor the C, but only the A vibrates in harmony with the tuning fork. So when some event in the previous waking experience, so to speak, vibrates in harmony with some fact of great importance buried beneath the threshold of consciousness then that mental fact is stirred into activity, and that is why when it forms its phantasies it uses the material, which, so to speak, brought it into being and which belonged to the world of reality of the previous waking period. One of my patients had a dream that took him back to his youth and to a setting in which important matters, emotionally, took place in his child life. In the dream he saw a gray fox, that was one of the central visualizations of the dream drama, but in his childhood days, although he had seen many foxes, he had never seen a gray fox. He had however seen red foxes. How does the fox of the dream come to be gray? He had been to the zoological park on the dream day and there seen gray foxes. Now is it not easy to see why? Because the fox stirred up an important association of emotional significance in his youth it started him to dream and although he had never seen other than a red fox in his youth the dream fox was gray because it was a gray fox the day before that had started the associations that stirred up the material out of which his dream was formed.

The next thing that I would illustrate and that I would speak of is the fact that dreams are highly symbolic. This should not frighten us when we remember that after all so much of our thought is symbolic. Every word is nothing else than a symbol, and even our ideas are only in the last analysis symbols of reality. Very much of our thought that we do not ordinarily consider as symbolic is really highly symbolic. But there is another reason why dreams should be symbolic. The dream is an excursion into the world of phantasy, the world of unreality, the world where the pleasure motive dominates. Now the pleasure motive as we have seen is opposed to the reality motive. Therefore if it is to come upon the stage and play its part it can only do so under the penalty of wearing a more or less complete disguise. The function of the dream is, in part at least, to conserve sleep. And so the play of the pleasure motive must be sufficiently disguised so as not to awaken the dreamer. The pleasure motive you will see therefore has been repressed as the reality motive has come to the foreground, and therefore it is the repressed expressions of the pleasure motive that come forward to expression in the dream. In other words the dream is wish fulfilling as we have seen, and it also contains as a rule the expression of some mental fact which in the waking life has been repressed.

A gentleman told me that he awoke with a consciousness of having been dreaming, but he could not remember any of the dream. He only had a conviction that he had either used or heard used during the dream the word diathesis. Now he said he had never heard the word diathesis, in fact so far as he knew there was no such word, so he felt that he must be mistaken and that the word was probably dieresis. He immediately got up and went to the dictionary to see whether there was such a word as diathesis. I asked him what he found the word diathesis to mean and he said "a tendency to disease." I asked him what dieresis meant and he said that dieresis was the mark that one made in writing indicating that something had been left out. Of course this is not the true meaning, but the significant thing is that it was the meaning to him. In the light of a little additional information the meaning of the dream was clear. The dreamer had been ill. The illness pointed pretty directly to the kidney as the offending organ and he had been afraid that he had a tendency to kidney disease. This fear he had repressed, had refused to look it squarely in the face and to regulate his life accordingly, but had preferred to act as if no such tendency existed, thereby endeavoring to delude himself into the belief that no such tendency in fact did exist. The dream shows the true state of affairs, shows his fears of kidney disease, the repression of this fear, and the wish that his diathesis, so to speak, might be eliminated, left out, which is the meaning that dieresis had for him. And so again in a simple dream fragment like this we get instantly, directly, and in a few moments right at the heart of the question. We find out exactly the thing that is worrying him, worrying him so much in fact that to one who knew him it was perfectly apparent that something had gone wrong.

Another example to show how the real vital worry of the individual may be read in the symbolism of a dream. The following is the dream, or perhaps a waking vision, for the individual claims that she was at least half awake, if not quite awake when it appeared. The percipient is a lady who some months ago while staying in Paris saw the following vision upon awaking one morning. From her bed where she lay she could look into the next room and see the piano. Standing behind the piano, therefore, only with face and shoulders visible she saw a woman. This woman was very pale, with dark hair, and had a brown hat on. That was all there was of the vision. The woman did not look like any one she knew, and she had absolutely no conception that this vision had any meaning other than that probably the drapery was arranged in a certain way so that it easily fell into form and made the vision, as we know it often does. But that cannot of course be an explanation. There must be some reason why it took just exactly this particular form. So my first question was, "What woman do you know who has a pale face?" Instantly she mentioned the name of a young lady, and I said "How about the brown hat?" and she said "I always think of her in brown because that is most becoming to her." I said then, "What does this young woman mean to you?" Her reply was that she always thought of her wonderful power of mind. She thought of her as under head control, too much perhaps for her own good. Now the meaning of the vision is clear. The vision is that of a woman who symbolizes for her, one who is under head control as opposed to heart control, and therefore she sees only the head of the woman in the vision. The thing that was in her mind therefore is symbolized in this way. Why? The percipient is a widow whose children have reached adulthood and therefore no longer require very much care on her part. She had only just sufficient means to take care of herself and absolutely no outlet for her activities or affections. She is temporarily stranded, so to speak, like a piece of drift-wood on the shore. She would have an interest in life and the dream shows that her aspirations are reaching out for a head interest now that all those for whom she has affection have been settled in life. The dream deals with the problem of her aspirations, her reachings out toward higher things in life.

We begin to get here into a still deeper meaning of the dream. We touch here upon its teleological significance. Here not only is the dream wish-fulfilling, but it gives us an idea of just what kind of thing it is that will put matters right. It points the way in which that individual must go in order to find fulfillment, and it therefore becomes of tremendous value in offering hints, in fact definite directions for the regulation of the life of the patient.

Let us consider another example. A young man dreamt that he stood before a coffin in which his

grandfather lay dead and as he stood there his grandfather's body moved and he turned his head to one side and appeared to be uneasy. I asked the dreamer what his grandfather meant to him and his reply was that his grandfather was his ideal man. So the meaning of the dream is plain. It meant for the dreamer that his ideal was dead, but that it did not rest easy in death. In other words, though dead it stirs and would live again. The dreamer instantly recognized the truth of this interpretation. He is a brilliantly endowed, active, keen-minded young man, cursed with enough money so that he does not have to put his nose to the grindstone and do the daily task. He therefore leads a dilletante existence in which he finds no true personal expression. His ideal is really dead, but in its death he is very unhappy. Here we see not only the meaning of the dream, but the tremendous important teleological significance of it. The dream says to the dreamer, "If you would be happy be up and doing, lead a life of usefulness, a life of accomplishment, and only in such a life can you find the fulfillment of your personality."

It will be seen in these dreams that the symbolism serves a very definite purpose, namely it clothes the dream in a language which is illogical to the dreamer. It therefore conserves sleep and permits the wish-fulfilling play to go on under such a disguise that the sleeper is not disturbed. The superficial aspect of the dream as the dreamer himself sees it and as he relates it is the *manifest content* of the dream. While the deeper meaning that lies behind the manifest content and which comes out when one is able to read the language of the dream is the *latent content* and contains the true meaning of the dream. The change of the latent content into the material of the manifest content is accompanied with a great deal of *distortion*, and the symbolisms in the above examples serve the purpose of this distortion of the latent content so that it is not recognized by the dreamer in the manifest content.

Another important mechanism of distortion is *displacement*. This mechanism results in displacing the emotion from the place where it belongs to some other element of the dream and thus serving to disguise the true meaning. A patient, for example, dreamt that she was pushed by a man off the edge of a precipice at the base of which was a mass of writhing serpents. In relating this dream the impression was derived that she had been very much frightened, but on analysis quite the contrary developed. There had been no special feeling of fear at all. The falling from the precipice into the mass of serpents was symbolic of a moral fall and should have created a great amount of emotion, but no such a motion existed in the dream, and therefore the dream is distorted to that extent and the possibility of its true meaning being known by the dreamer is greatly interfered with. The telling of the dream, however, which led to the impression that great fear had as a matter of fact been experienced was the result of another mechanism, namely the mechanism of *secondary elaboration*. After the dreamer awoke and remembered the dream, the dream naturally appeared senseless unless the emotion of fear or horror were attached to the experience, and therefore the waking consciousness in order to make the whole thing appear logical attached the emotion where it apparently belonged, giving meaning to what was otherwise without meaning.

In describing the above mechanisms of dream formation it has been seen how the latent content is disguised before it is permitted to appear in the manifest content. This disguise is brought about by what Freud terms the *endopsychic censor* of consciousness. This censor permits only certain expressions to get into the dream. The thoughts of the patient can appear only under certain restrictions and under certain disguises. The distortion, the displacement, the symbolization serve the purposes of this disguise.

It must not be thought, however, that it is simply necessary to read the symbols of the dream in order to understand fully the latent content. The dream is a tremendous *condensation* of a vast amount of material, and all of the elements as they appear in the manifest content of the dream are determined from many sources—they are *overdetermined*. For example, an individual may appear in the dream who is entirely unknown to the dreamer, a person who does not look like any one he has ever seen before. An analysis of the dream, however, may show that if the characteristics of this person are separately considered each of them belongs to a person known to the dreamer and that the dream person therefore is a sort of composite of these several characters which are united in this way to serve the purposes of the dream. An example will illustrate some of these mechanisms.

The patient dreamt that she was in a place of amusement, something like a circus, where there were crowds of people. She met many strange people, among others, a young lady to whom she took quite a fancy, and who invited her to stop in her home on the way back from the fair. She met there this young lady's mother, and they were very pleasant and nice to her, so that she in turn invited the young lady to a party at her house. She seemed to be living in her present home. She also invited a man to the party at the same time, a man with red hair and blue eyes. Some time elapsed, and then she called on this girl, by invitation, for the afternoon. During this intervening time the girl had married and had a baby, and remodeled her home inside and out, and put in all modern conveniences. She took her through and showed her everything. They had a pleasant time, and she again invited the young lady to her home and told her to bring the baby along, and she also invited the red-haired man, who also had married in the meantime and had a child. He did not let her know, however, that he had married, as it would be a surprise. She and he were both surprised. The children were about the same age, and everybody had a good time at the party.

In the course of the analysis of this dream it appears that she had forgotten to tell all of it. The portion forgotten was that there was another man in the dream, a dark-haired man, but she didn't seem to pay any attention to him. He seemed to have his back toward her. As far as she could tell, he looked like two men that she had liked.

We have here an example of *condensation* and *identification*. The young lady that the dreamer met at the place of entertainment, and whom she became friendly with, really represented herself in the dream. Let me give the reasons why, and some of these reasons are based upon things which I had learned in the analysis previous to the dream.

She had, a few years previously, had a love affair with a young man with red hair and blue eyes, and he had asked her to marry him. She had refused, however, because she thought her duties at home required her to help care for her mother and support the household while her brother was going through college. She had been introduced to this young man by another gentleman, and when this other gentleman found that matters were getting serious between the two, he had, unknown to her, a conversation with the red-haired man in which he advised him not to marry the patient, as he did not think they were suited to each other. Sometime after her refusal, the man who introduced them called her up on the telephone one evening and told her that the red-haired man was being married that night. This was, as you may imagine, a considerable emotional experience. The dark man who stood with his back to her in the dream was the man who had introduced them, and this illustrates the point that Freud makes that the little addendum to the dream which has been forgotten in the original account, usually contains the key to the situation. The young woman with the baby in the dream, who

represents, I say, the patient, is very completely disguised, so that the identification is not discernible. The patient herself was a woman with dark eyes and black hair. The young lady of the dream was a decided blonde. In addition to this, the dream girl was slender, while the patient is decidedly the opposite (simple distortion by opposites). The dream girl was not accompanied by her husband, and he did not appear to enter at any point in the dream, either by reference or supposition or otherwise. Incidentally too, the red-haired man was not accompanied by his wife, and his wife appeared also to be as absent in fact as the husband of the girl. The girl also wore a tailor-made suit of a brown color. The patient had had a tailor-made suit herself, but not of that color, but she had had another dress that was of the same color but was not tailor-made, and this dress which was the color that the dream girl wore was the dress that she had worn upon the eventful night when she had had the disagreeable sexual experience which resulted in her psychosis. The patient also says that the dream girl acted as she might have acted, and had in the dream what she really wanted. Further complications are that the dream girl looked like the sister of the red-haired man, who was a woman who wanted to marry but did not want children or to keep house, while the sister of the dark-haired man who introduced them had a light-haired baby boy. She experienced the feeling also that she was worried in the dream because both of these people had babies and she did not, nor did she have any sweetheart, nor in fact did she have anything. The censor of consciousness made the disguise so complete that the patient could not recognize it and was therefore not disturbed by it. Further reasons for believing that this was an identification are, in the first place, the patient describes herself in the dream as being present at the party but nobody paid any attention to her, nobody spoke to her, and the events of the party went on with apparently no one having anything to do with her—she was merely an onlooker. In other words, the dream had put her in the position where she could view herself and her acts. Then the dream girl had no husband, and the dream man had no wife. The two babies in the dream now have to be accounted for, and further emphasize the process of *identification* which is a phenomenon of the broader process of *condensation*, and still another process, that of *decomposition*. She had really been in love with this man and had regretted that she did not marry him. She therefore had the natural woman's wish of wanting his baby. The baby of the red-haired man in the dream had red hair and blue eyes. It is consequently evident that it is his baby, but how about the other baby of apparently the same age? The dark man who introduced the two had a sister who had a light-haired baby boy. Now this boy the patient had been very fond of. It is therefore quite evident that the two babies represented a decomposition product. The red-haired baby is the wish baby of the man with whom she was in love, the light-haired baby is the real baby for whom the patient had an affection. The patient, therefore, wished for the baby of the man she loved, for whom she might have the love and affection that she had learned to have for the real baby that had been in her experience. The dream therefore expresses a wish for marriage to the man loved and a desire for his baby.

If I have made myself clear in the fore part of this paper regarding the conflict between the pleasure motive and the reality motive and the resulting necessity of compromise and the ease with which a flight may take place into phantasy when difficulties arise in the world of reality, it will be seen that dream and phantasy formation have their origin in conflict and when a person leads a very active life of phantasy one has a right to assume that he is not fully at one with himself. Now to proceed a step further by the statement that in proportion as the reality motive succeeds the tendency of the individual is toward higher and higher levels of development, and in proportion as the conflict results in the failure of the reality motive the individual is plunged back into the world of phantasy, he recedes to lower and lower cultural levels. Therefore we should be prepared to see in many dreams phantasies which picture the world as if seen from the eyes of a child or a more primitive people, phantasies which use the symbolism of cultural levels that are lower than that in which the dreamer lives in his waking life. In other words we should be prepared to see in the dream a regression to lower levels and therefore the dream, over and beyond the fact that it is wish-fulfilling and in addition to its teleological significance, may have certain genetic implications that are of importance to consider.

A gentleman of somewhat advanced years told me that he had dreamt that he was two logs of wood, each in a different hotel and that he could not get the two together. Here we have a dream that gives certain hints in the way of genetic origins such as I have just indicated. On the surface the dream very plainly symbolizes the conflict which has split the man in two. As a matter of fact he had started off as a young man to follow a certain course of life. He had been deflected from this course by certain circumstances, his deflection had stretched out from weeks into months and from months into years, and he never succeeded in getting back on the right path again. He has practically spent his whole life in a line of endeavor which was distasteful to him, always wishing that he might have lived the other life.

For our purposes, however, the important thing is this man's associations with wood, for the significant thing of the dream is why he should have used wood to symbolize himself. His associations with wood are unexpected, they strike one as unusual. They are three: fire, cooking, and ashes.

To give the full genetic interpretation of a dream of this sort would require considerable space. I will only give some brief hints. The wood here is probably in a general way symbolic of the mother and would mean that the patient would go back to the beginning and start over. In the older days, during the early period of history and in prehistoric times wood had very great significance. I have only to recall the perpetual fires tended, for example, in Rome by the Vestal Virgins, to show the great importance which wood and fire had in early religious beliefs and observances. The whole continent of Europe was covered with immense forests and the trees and the wood played important parts in the religious observances of that day. Fire was a tremendously important thing to the primitive man and from his point of view the fire resided in the wood. It was brought forth by a process of boring which offers a very crude symbolism well set forth in the language which always attributes the masculine sex to the borer and the feminine sex to the bored. And so the child is resident in the mother and comes forth from the mother much as fire is resident in and comes forth from the wood. We have here the very close connection between fire and cooking, for the life that is in the wood is transmitted to the food through the fire. I am reminded in this connection of the association of a psychologically seven year old child to the word mamma. Asked what mamma meant the child replied, "To eat." And so here we find a close association between the mother and nutrition, between sex and food. In further elaboration of the symbolism of fire I may mention the expressions in common use by the people, who speak of the fire of love and the fire of life and the warmth of life as opposed to the coldness of death, the flame of life, etc., and recall that the Vestal Virgins who tended the perpetual fires often bore children to the God when they worshipped and they were then sup-

posed to have been impregnated by the sacred flame. So that we get the deeper meaning of this dream as a desire to go back to the mother. In addition to this we have the association ashes. Now this man had a cardiac lesion and lived in more or less constant fear of death. A severe conflict in the personality which splits the individual in twain, is the result, as will be seen if I have made myself clear, of the domination of the pleasure motive, or more properly speaking the failure of the reality motive, the inability of the individual to bring himself into efficient relationship with reality and therefore the regression of his interests to lower levels. This condition of affairs leads to what amounts to death—it tends toward psychic death. The individual who has withdrawn his vital interests from the world of reality, who has slipped back into the world of unreal phantasies, who no longer has vital touch with the real world, that person is dead, not physically dead, but mentally dead. Such patients will say that the world all looks dull and gray to them, nothing excites their interest, they do not care what happens, mother, father, brother, sister, children may die and no effect is produced upon them, and when this condition has continued for a considerable time they will say that they themselves are dead, that their blood no longer circulates, that they have no heart or brains. And so from this beginning are developed a long list of negativistic delusions. The man who has a vital, active, impelling interest in life, even though he has a heart lesion, has not time to be bothered about it. It does not worry him, he has other things to think of.

And so in this little dream of the two pieces of wood we not only get the epitomized history of this man's life, but we see a deeper significance, reaching back through the ages of mental development, and come to realize how some of the mental states with which we are familiar may have grown.

Of course it must be understood that I do not mean literally that this man brings over recollections from his ancestors. The wood and the fire and the cooking and the ashes have all been experiences in his own individual life. The only thing that I mean to say with regard to them is that he utilizes them in a primitive way. The crucial question that one might ask regarding his dream is not why he represents himself split in two, that is understandable, but why he chooses wood to symbolize himself. Herein lies the archaic method of utilization of the facts of experience.

Another mechanism of the dream is of very great importance for practical purposes. It is the mechanism of *transference*. In the course of a psychoanalysis there comes a time when the patient begins to dream of the analyst and the way in which he is dreamt about shows precisely what effect he is producing upon the patient. The dream shows whether he is taken seriously or not, whether he is regarded with respect, and with regard to specific elements of the analysis the dream often shows just how far the analyst may proceed. In short the dream shows not only whether a rapport has been established between the patient and the analyst, but precisely the nature and limitations of that rapport, and so becomes a delicate measure by which the analyst can estimate the progress of his work. Such a transference dream follows.

A patient dreamt that she was at the National Theatre to hear Aida. She saw me there with a dark-haired lady with brown eyes and a black silk dress with white dots, and a diamond ring on the engagement finger like that which her sweetheart had given her. This dream illustrates many things. In the first place, it illustrates the fact that the dream utilized material of the preceding waking state. She had had someone read to her the day before something about the opera Aida, and I had taken a young lady through the wards, who had worn a dark dress, and who had dark hair and brown eyes. The analysis showed: First, as regards the black silk dress with the white dots. She herself had always been fond of black. As regards the face of the lady, it was a full round face, with brown eyes, and as regards the individual, she was vivacious, animated, and gestured a good deal with her hands in talking. This description tallies with the description of the young lady I had taken through the wards. It is significant also that it tallies with the description of the patient, who said that she used to use her hands a good deal in talking. The age of the dream lady and the patient appeared identical. Further detailed descriptions as regards the teeth, character of the hair, the skin, the lips, the weight, were all equally applicable to the lady whom I had taken through the wards, and to the patient. And when I had asked her if there was anything in the dream that reminded her of her former sweetheart she said that it made her think of the lovely times they had had together at the opera.

This dream illustrates a phenomenon of condensation in which an element in the manifest content of the dream, namely, in this case, the dream lady, is made up of components of two or more other persons. It is quite evident here that the dream lady is made up of components both of the lady whom I had taken to visit the ward, and the patient herself, and becomes, therefore, a special form of condensation known as identification. The patient identified the dream lady with herself. In the same way it will be easily seen that I was identified with her sweetheart.

In this dream it is easy to see the tender regard with which the dreamer thinks of the analyzer. In another transfer dream a patient saw herself in prison. While there she learned that a great inheritance had been left to her in England, but she could not get it because she could not leave the prison. The judge would not permit her to receive this inheritance unless she made herself worthy of it. Here the judge is the analyzer, and the patient, who, so to speak, has a God-given inheritance, is unable to come into it while under the restrictions of her neurosis. She must make herself worthy of her great inheritance, and the judge, the analyzer, is to determine when she is worthy. In such a dream as this the very great respect this patient has for the analyzer and for his judgment and authority is easily discernible.

In another transfer dream the analyzer appeared under the disguise of another person who was permitted to enter the private room of the patient. This dream symbolized the permission which the patient for the first time had given the analyzer to deal with her intimately. Up to that time she had been quite inaccessible.

Up to this point, then, we have come to see that *the dream is a wish-fulfilling dramatization*. Although words and sentences and speech occur in dreams they are for the most part visual in content. We have further seen that the dream takes its immediate origin from the events of the previous waking state and uses these events to clothe the dream thoughts. These thoughts which constitute the *latent content* of the dream are disguised in the process of appearing in the *manifest content*, principally by the mechanisms of *distortion* and *displacement*, and finally by the *secondary elaboration* of the waking consciousness. These thoughts appear as a result of these distorting mechanisms as a rule in highly symbolic form, and it is necessary to learn to read symbols in order to understand the dream. As a result of this distortion the dream thoughts as they appear in the manifest content have a surface value quite different from their real value, so that the real dream thoughts undergo in the dream a "*transvaluation of values*." The emotions, however, remain the same, but are displaced in the manifest content of the dream. So we find experiences that should be emotional without emotion, and inconsequential happenings emotionally ladened. This latter circumstance has led to the generalization that

*the affect is the only truth of the dream.* The reason for the distortion and disguising of the dream thoughts before they appear in the manifest content is that they refer to desires or wishes of the individual which have been repressed as being inacceptable to the waking consciousness. One of the functions of the dream is to conserve sleep. Therefore the *endopsychic censor* of consciousness insists upon the disguise of these repressed desires, otherwise by their surprising or perhaps horrifying non-conformity with the patient's personality they would cause him to awake. There are a few dreams which show the sleep-conserving wish-fulfilling mechanisms with regard to matters that are not repressed and therefore not distorted, more particularly such dreams as the so-called "convenience dreams," a dream for example in which a person who is thirsty at night dreams of drinking quantities of water, thereby slacking his thirst and continuing to sleep.

In addition to the above characteristics of the dream, Freud, by a series of exquisite analyses has sought to demonstrate that the dream can arise only on the basis of infantile repressed material, in other words that the wishes that are in or near to consciousness must touch at some point and harmonize with the repressed, long-forgotten infantile desires, and that it is only when this situation arises that a dream occurs and that the dream represents the fulfillment of both wishes.

It will be seen from the above, therefore, that the dream shows what is really going on in the personality, that through it it is possible to attain to the real thoughts of the individual, and that if it is possible to analyze the dream, not only will an immense amount of material be uncovered which would be largely hidden otherwise, but that it is possible to penetrate to the very depths of the personality, even into the realm of the unconscious, the long since forgotten, the infantile. In the neuroses, the psychoneuroses, and in many of the psychoses this sort of information is of the utmost importance and is the only way in which one can get at an understanding of the symptoms which on the surface appear so illogical and unmeaning. The analysis of dreams, therefore, becomes an important matter in dealing with mental disorders.

The method of dream interpretation is important to understand because it goes without saying that the dream cannot be interpreted simply from hearing it recited by the patient. There must be some method of procedure to find out the hidden meanings. In the first place, the patient tells the dream. With a realization of all of the things that have been said with regard to the mechanisms of dream formation, distortion, symbolism, and the rest, we shall see that the problem is to determine what the different elements of which the dream is composed really stand for in the patient's mind. The interpretation of the dream, therefore, begins in the very telling of it. The patient must be under constant and careful observation and it must be realized that everything the patient says, no matter how meaningless, not only probably has meaning, but must of necessity have meaning. It is therefore of great importance to notice all the little hesitations, corrections, mistakes in speaking, changes in expression, and it is even desirable often to get the patient to repeat the dream to notice wherein the second account differs from the first, because these differences present highly significant points of attack in the interpretation.

Proceeding now from the hints that we have derived from the original telling of the dream, the method of "free association" is used. A single element of the dream is taken, for example, a house, a river, or what not, and the patient is asked to tell everything that comes to his mind regarding it, being especially warned to observe no critique whatever in the selection of the thoughts which he will tell, no matter how absurd or inconsequential they may appear to him. To use the example given by Freud, he must tell all of the thoughts that come to his mind just as they occur as if he were a traveler looking out of the window of a railway train and recounting seriatim the things he saw as he went by. In this way the underlying material which has been condensed into the symbol of the manifest content is brought to light and the meaning of the symbol emerges. It is often comparatively easy to get at the meanings of dreams on their higher levels, but the deeper meanings, particularly those that reach back into the unconscious, are quite usually extremely difficult to fathom and it may be only after many hours of patient effort and after a pretty fairly complete understanding of the patient that their meaning can be read.

One has always to avoid the temptation of reading meanings into the dreams. One who is familiar with dream symbolism realizes that certain things generally have certain fairly definite meanings in the language of the dream, but one should also realize that these meanings are never universal, that in a particular dream of a particular patient a given symbol which usually means a certain thing may mean something entirely different, and that even if it does mean the usual thing in a general way, the patient may have given it some special individual variation of his own. The underlying principle of symbolism is that anything may symbolize anything else. Further than this, because of the ambivalency of our thoughts and feelings we tend to associate with a given attitude of mind not one that is simply different, but one which is diametrically opposed, so that a given symbol in a dream may mean what it appears to stand for, or, on the other hand, it may mean the exact opposite. In fact one of the common disguises of dream formation is the process by which events are exactly reversed. This is quite common in the so-called birth phantasy dreams. One of my patients, for example, had such a dream. It was very complicated, and I will only mention that he fell into the water and after swimming around for a while, swam into a large cave through a small opening. The elements of this dream were reversed and if he be considered as coming out of the cave through the small opening into the "waters" it will be seen that the sequence of events corresponds to a birth phantasy. We therefore have to be very careful in the interpretation of dreams and insist, so to speak, that the patient give us the meaning, that we continue the process of free association until the meaning is evident, until the patient sees it, until therefore the meaning has dawned upon him without assistance from the analyzer. We thus are enabled to get at the true meaning of the dream images, having merely instructed our patient in the method of procedure.

The theory of the method of free association is a simple one, namely, that if one begins with some element in the dream and tells all the thoughts that come to his mind, those thoughts are of necessity associated with the dream fragment, and therefore have to bear a definite relation to it. If enough of these associations can be gathered, all of which necessarily relate in some way to the dream fragment, the meaning of the dream must necessarily emerge.

Of the general principle that the dream never deals with trivialities, is always engaged in bringing to pass something which is close and dear to the soul of the dreamer, the importance which dream analysis plays in the understanding of mental conditions is evident.

Not only is the dream important as the open door to the personality, but its analysis has disclosed the operation of certain mental mechanisms that are fundamental in the psychic life. These mechanisms are operative in all people. An understanding of them is necessary for the understanding of normal psychology, and Freud has shown in his "Psychology of Every Day Life" that they are responsible for all

manner of slips of the tongue, forgettings, peculiar actions, and the like. An understanding of these mechanisms is essential to the understanding of character, and character is modified and differently builded in accordance with their varying operations.

Not only are the mental mechanisms which are disclosed by dream analysis important for the understanding of normal character traits, but they are the same mechanisms that are found operative in the psychoneuroses, hysteria, and the compulsion neuroses, and in many at least of the psychoses, particularly in dementia præcox. An understanding of these conditions can be reached only by an appreciation of the special interplay of these mechanisms operative in the particular case. The dream, therefore, becomes of fundamental importance in the whole realm of mental phenomena. WILLIAM A. WHITE.

**Drepanidotænia.**—A subdivision of the genus *Hymenolepsis*. In these tapeworms the hooks have the dorsal root much larger than the ventral, and are only eight to twenty in number. *D. lanceolota*, though it is usually found in birds, is sometimes present in man. See *Cestoda*. A. S. P.

**Dressings, Surgical.**—SUTURES AND LIGATURES.—A *suture* is a material employed to approximate wound edges or surfaces. A *ligature* is a material used to constrict tissues, and commonly to obliterate the lumen of blood-vessels. With few exceptions the same material is suitable for both purposes. Various substances are employed, and are divisible into those that are absorbable and those that are non-absorbable. These also vary in strength, flexibility, capillarity, and difficulty of sterilization.

Of the absorbable materials, *catgut* is the one most widely used for sutures and ligatures. It is derived from the submucous coat of sheep-gut. It is made in sizes of which 00 is the finest and 6 the coarsest. It is absorbed within a few days, unless treated with chromic acid, when absorption may be delayed as much as three weeks. Methods of sterilization are numerous and include treatment by dry and moist heat, iodine, cumol, alcohol, formalin, bichloride of mercury, and silver salts.

*Kangaroo tendon* is handled like catgut, but is stronger and more slowly absorbed. Aluminum bronze and phosphor bronze are thin metallic sutures that are easily sterilized by boiling and ultimately absorbed.

Of the non-absorbable materials *silk* is the oldest and best known. It comes either twisted or braided, in white or black colors, and in various sizes up to 9. It is readily sterilized by boiling, possesses considerable strength, and may be knotted far more securely than catgut. Its widest use has been in intestinal suturing, but recently it has again been gaining favor for all soft tissues. It is contraindicated in the presence of infection, where it will keep a sinus open until removed.

*Linen.*—"Celluloidzwirn" or *Pagenstecher thread* is prepared by impregnating linen thread with celluloid. It is handled similarly to silk, but is a bit stiffer. It is supplanting silk in intestinal work. It has practically no capillarity.

*Silkworm gut* is obtained from the silk glands of the silkworm. It is readily sterilized by boiling. It is a favorite suture for approximating skin edges, though often employed as a through-and-through "tension" suture for the abdominal wall. It must never be buried. A single knot usually secures it, and the ends should be left about an inch long. A strand folded on itself several times affords good drainage for small wounds.

*Horsehair*, derived from the tail of a horse, is light, strong, and flexible, with capillarity, and is quickly sterilized by boiling. It is an ideal skins uture, especially where the skin is tender and delicate, as on the face. Like the preceding material it is not to be buried.

*Silver wire* is used in bone work, typically in approximating the fragments of a broken patella. It probably has antiseptic qualities and, according to some, stimulates osteogenesis. Its cut ends must be imbedded in the bone, for they are mechanically irritating to soft tissues.

DRAINS.—Materials commonly employed for drainage are silkworm-gut strands, guttapercha, rubber dam, rubber tubes, glass tubes, gauze, and a combination of gauze enwrapped in rubber (cigarette drain). Silkworm-gut strands are satisfactory for drainage of subcutaneous areas. Strips of guttapercha and of rubber dam are useful in superficial wounds, and also to maintain drainage after removal of a tube. A rubber tube fills the requirement of a deep, freely-discharging wound. It must be of fairly large size, as small tubes readily become plugged. It is prevented from falling into the wound by transfixion with a safety-pin. It must be frequently rotated in the wound, lest its openings become occluded by the surrounding tissues. A rubber tube is seldom required more than a few days, owing to its tract being obliterated by granulations. As the tract fills up from the bottom the tube is shortened day by day. A glass tube finds its use chiefly in suprapubic drainage where, after twenty-four or forty-eight hours, it is usually replaced by a rubber tube. Its projecting end is flanged, so that it is not likely to fall into the wound. It may cause gangrene of the gut from pressure, and of course is liable to breakage. Gauze is mentioned last because it is the most misused material in drainage. The principle upon which the employment of the preceding materials is based is that if an open channel to the surface be maintained the walls of the abscess cavity will contract and drive the pus to the exterior. Gauze, on the other hand, acts as a wick in a lamp but, except in large wounds where the discharge is thin, soaks fluid up to the point of saturation and then acts as an efficient plug, behind which the remaining secretions dam. For these reasons it should never be used in peripheral and superficial wounds, and in those discharging thick fluid. A piece of gauze impregnated with sterile vaseline is the equivalent of a rubber-dam drain. For drainage of deep abdominal wounds a dossil of gauze enwrapped, except at its ends, with rubber dam is very satisfactory.

DRESSINGS.—*Surgical gauze* is cheese-cloth boiled in a solution of carbonate of soda to remove the sizing, thereby increasing its absorptive property. The selvage is the tape-like edge of the gauze bolt as it leaves the manufacturer. Gauze has entirely replaced the older materials of linen lint, charpie, tow, oakum, and jute, as well as marine sponges, which are difficult of sterilization. It is fashioned into a variety of shapes, according as to whether it is to be used as a sponge, a pad, as packing, a bandage, or simply as a covering for a wound. Old used gauze may be raveled into the form of the charpie of olden times to form a substitute for absorbent cotton. Gauze may be medicated with a variety of drugs, including boric acid, carbolic acid, corrosive sublimate, double cyanide of zinc and mercury (Lister's cyanide gauze), and iodoform. Boric acid gauze is useful in eye dressings. Carbolized gauze, five per cent., and other antiseptic gauzes prevent saprophytic infection of wound discharges. Iodoform gauze is made by impregnating gauze with sterilized iodoform to which are added glycerin, alcohol, and bichloride of mercury. It is used chiefly in tuberculous areas and to deodorize stinking discharges. Iodoform gauze is but weakly bactericidal,

its chief virtue being that it stimulates leucocytosis and therefore phagocytosis. Gauze is the best material for packing and the poorest for draining thick fluids. Gauze bandages are light and cool but are apt to curl up and become displaced, and do not afford the support of a muslin bandage. Gauze makes an excellent scarificator for vaccination.

*Lint* is a light canton flannel, one side of which is soft and cottony and the other smooth. It is used to spread ointments upon, for which the smooth side is employed, since it is more difficult to spread the downy side.

*Surgical cotton* is absorbent or non-absorbent and, like gauze, may be medicated. Absorbent cotton is used chiefly for making topical applications, as well as for wiping wounds and surfaces, and for tampons. When used as a sponge, cotton should be wrung out in water, for otherwise loose, dry fibers will be detached. Non-absorbent cotton is used over the dressing and under the bandage to equalize the circulation of an inflamed part, under a gypsum case to keep the gypsum from traumatizing the skin, and to pad splints.

*Surgical wool* may be used for the same purposes as non-absorbent cotton, than which it is more elastic, though more expensive. It is also used for vaginal tampons.

Protective.—A protective is a smooth material used usually over an extensively granulating area to prevent the mechanical irritation of gauze. The newer protectives are Cargile membrane, egg-membrane, and amniotic membrane, although Lister's oiled silk, mackintosh, guttapercha, and silver foil are still extensively used. If there be much discharge from the granulations maceration may be avoided by impregnating fine-meshed curtain fabric with a mixture of white wax and Venice turpentine, thereby obtaining a flexible, smooth, non-irritating but *pervious* protective. Paraffin paper is employed to retain heat and moisture in wet dressings. By crinkling it up and then unravelling it, better adaptation to the surface of the dressing is obtained, and there is not so much tendency for the bandage to slip.

Adhesive Plaster.—Adhesive plaster is employed to approximate skin edges in place of sutures, to retain dressings, to support parts by strapping, to immobilize parts, and as an agent by which traction may be applied to a limb. The best plaster for use about the face is flesh-colored silk isinglass plaster, because it is inconspicuous and is readily removed by moistening with water. The old-fashioned resin plaster, the adhesive quality of which is developed by heating, is still the least irritating to the skin, and is still the best for a long period of application, as for strappings. Rubber plaster is useful for retaining bandages, but not for direct application to the skin, since it is liable to irritate. When medicated with zinc oxide, however, it may be used upon the skin. Before applying plaster directly upon the skin the part should be carefully shaved, so as to render the removal less painful. The best method of removing plaster from skin is to saturate it with benzin, which dissolves the rubber base. Moleskin plaster is much thicker than the others, and is used by Rose for his abdominal binder for splanchnoptosis. Where frequent renewal of dressings is necessary on the trunk, short broad strips of resin plaster may be placed on both sides of the wound, tapes tied into their edges, and the intervening space spanned by tying the tapes over the dressing.

Forms of Dressing.—After certain wounds, for instance after removal of an aseptic cyst or tumor from the face, upon insertion of the sutures no dressing is required, it sufficing merely to paint the apposed edges with tincture of iodine. This prevents infection of the edges until they are sealed together by plastic lymph. Another good dressing for sterile wounds is a bit of dry gauze held to the skin by flexible collodium. This dressing is contraindicated in the presence of infection. It is best removed by lifting up one edge with a pair of dissecting forceps and pulling it off. Gauze dressings are employed dry for first-intention wounds and where there is but scanty discharge and no acute inflammation, and wet where the opposite obtains. A dry dressing is retained either by zinc oxide adhesive strips or by a roller bandage suitably applied to the part. For a wet dressing gauze is saturated with plain sterile water or with a chemical solution. A plain sterile water dressing is one of the best, as it fulfills the indications for warmth and moisture, and does not harm the tissues. For devitalized tissue an isotonic normal saline solution is best. If free drainage is desirable and must be encouraged, Wright's sodium chloride-citrate answers well. Many surgeons are satisfied with boric acid solution. Wet bichloride dressings are obsolete because corrosive and irrational, while wet carbolic acid dressings may cause gangrene. It is hard to excel a 70 per cent. alcohol dressing, especially for stinking wounds. Over the wet gauze paraffin paper should be applied to prevent evaporation, and over this a layer of non-absorbent cotton as a compress to equalize the circulation and to prevent constriction by a tight bandage. The bandage is best secured by safety-pins if on the head, and elsewhere by rubber adhesive strips. It may also be stitched together.

If it is desired to stiffen the bandage for purposes of immobilization, it may be enmeshed with sodium silicate or plaster of Paris. Sodium silicate (liquid glass) is applied with a brush between the layers of a gauze bandage and after about twelve hours, when dry, forms a light but rigid case. Plaster-of-Paris bandages are placed in warm water until air bubbles cease rising and are then applied to the part over a layer of non-absorbent cotton. Within an hour or two there results a hard gypsum case, which may readily be removed with a sharp heavy scalpel. For leg ulcers Unna's dressing of zinc oxide, gelatin, glycerin, and water is excellent.

Morris Booth Miller.

**Dropsy.**—See *Ascites and Edema*.

**Dropsy, Epidemic.**—An acute disease of unknown cause, probably infectious, and characterized by fever, dropsy, and in some cases an erythematous eruption.

The first recorded outbreak of the disease was at Calcutta in 1877, following upon an extensive famine in Southern India. The disease persisted in epidemic form in Calcutta till 1880, the number of cases increasing in each cold, and falling off in each hot season. It has continued to appear there sporadically. Epidemics have occurred elsewhere, notably in Bengal in 1902 and 1907. The disease has been reported only in India and in Mauritius.

The cause is unknown. It appears to have been carried from place to place by the migration of laborers, and it seems probable that the communication from person to person is indirect. The bedbug has been suggested as a probable carrier. Direct contagion does not seem to occur. No physician in attendance upon cases has ever contracted the disease.

At autopsy, the large serous cavities are dropsical; the gastrointestinal tract is often intensely congested, sometimes ulcerated: the kidneys are congested, sometimes with cloudy swelling; and the heart is dilated.

The attack begins usually with fever (100°–104° F.) and with a dropsy in the lower extremities. As the disease progresses the dropsy mounts to the abdomen and upper limbs, sometimes to the face. Hydropericardium and hydrothorax embarrass the heart and respiration. An erythematous rash frequently

appears on face, trunk, and limbs. From the first there is anemia, erythrocytes and hemoglobin being reduced often to sixty per cent. of the normal. The leucocyte count is not materially altered, an eosinophilia of five per cent. or more being referable to other causes (coexisting parasitic infections). There is no albuminuria. The duration of the disease varies from three weeks to three months.

The diagnosis from the wet form of beriberi is made on the presence of fever; persistence of the knee-jerk; absence of anesthesia and paralysis; absence of pain on squeezing the muscles.

The prognosis, except in the aged, is usually favorable. The mortality ranges from two to eight per cent.

Treatment must be symptomatic and expectant, rest in bed, rational antipyretic measures, nourishing diet, mild catharsis, cardiac stimulants, and during convalescence iron for the anemia. J. F. Leys.

**Droseraceæ.**—(*Sundew Family.*) From a biological point of view, this is one of the most interesting families of plants, owing to its carnivorous properties, as typified in the much celebrated Venus' fly-trap. Since this tendency to secrete flesh-digesting fluids is shared, to a greater or lesser extent, by other plants in the family, questions have been prominent as to whether they might not be utilized as digestants. The use which has been made of those species which are utilized in medicine has, however, not been chiefly in this direction, but as pectorals of an anodyne character. The species so used are of the genus *Drosera*, or sundew, which drug has been introduced into the National Formulary. Aside from its proteolytic enzyme, it contains an aromatic and acrid greenish-brown resin. To some extent they have been utilized as carminatives and gastric anodynes. The dose is gr. v. to xxx. (0.3–2.0).

Henry H. Rusby.

**Drosophila.**—A genus of flies. *D. ampelophila* is the common fruit fly, which sometimes breeds in human excrement. On account of the ease with which this species is reared in the laboratory, it has been much used for experimental work in heredity and for other purposes. A. S. P.

**Drowning.**—To drown means literally to submerge in a liquid, and is used here to indicate especially suffocation in water. In such cases life usually becomes extinct in from one to five minutes after water enters the lungs. In this connection, Draper records the instance of Prof. Enochs, who was able to remain under water four minutes and forty-six and one-half seconds. Draper also mentions the report of the United Life Saving Service of the resuscitation of Stanley S. Holmes, aged five and one-half years, after an immersion of twenty-five minutes, signs of life reappearing at the end of forty-five minutes. Cases are recorded in which recovery has occurred after working with the patient for over four hours. It is commonly believed that attempts at resuscitation will not be successful after the heart has stopped, but that is doubtful; at any rate, it is often difficult for one to be certain that the heart has actually stopped entirely, so that efforts at resuscitation should be made in every case in which there is not positive evidence that the patient is dead.

In cases of death from drowning, the skin is pale or slightly livid, the body is bloated if it has been for some time in the water, froth appears at the mouth and nose, there are abrasions or excoriations of the skin and retraction of the penis, the tongue is swollen and congested and closely applied to or clenched between the teeth, and the muscles of the hair bulbs are rigidly contracted causing cutis anserina or goose skin. The air passages are congested and filled with frothy mucus more or less tinged with blood. The lungs are edematous and pit on pressure, and sanguineous fluid may be expressed from them. Sand, mud, and small particles of weeds may be found drawn deep into the air passages. Often water will be found both in the stomach and in the pleural cavity, and usually the brain is congested.

The heart usually stops within two or three minutes after the cessation of respiration, and five minutes may be regarded as the maximum. The brain centers may be resuscitated after the circulation has ceased as long as seven minutes. Crile has suggested the injection of adrenalin in saline solution into the radial artery toward the heart. It is possible that a shorter route may be found to the general circulation than via the radial artery. At any rate, such an injection, to be of value, must be given within twelve minutes after the cessation of respiration. The object of the injection of the adrenalin-saline solution is to support the heart, through raising the blood pressure in the coronary vessels. Obviously, it must reach the heart to accomplish this object.

Infants, especially very young infants, bear submersion better than adults. This fact has been noted also among animals. For instance, in the execution of dogs by the humane societies, where drowning is used for that purpose, the young puppies are notably resistant, often recovering after prolonged submersion. Many of the pounds do not attempt to kill the puppies for this reason until they are a number of weeks old. This interests us as physicians, who are engaged in the attempt to prolong life, since it encourages us to greater effort to resuscitate infants and children after prolonged submersion. This resistance of infancy to drowning has been attributed to the recent aquatic existence of the infant, but it is more rational to attribute it to the preponderance of the vegetative phase of life in the infant and the comparative absence of terrorized struggling.

The recognition in the lungs of the fluid in which the individual has been drowned is not practicable, since it does not differ as a rule from other fluids, such as may be found in edema. In some cases, as in drowning in sewers or vaults, characteristic particles may be found both macroscopically and microscopically in the respiratory passages as far as the smallest bronchi and even the alveoli.

In experimental drowning of animals in colored fluid, it has been found that the fluid always enters the lungs, but less with the first inspiration than with the inspirations that occur after the loss of consciousness, and most is inspired during the late attempts at respiration, after the violent struggling has ceased and asphyxia is pronounced. The first fluid that enters the respiratory tract is expelled by the expiratory cough that its presence induces.

In the drowning of animals, the healthier and stronger the animal, the larger will be the quantity of fluid inspired. And the converse is true, the more emaciated and weak the animal, the less will be the quantity of fluid that will reach the lungs.

Death from drowning is due to asphyxia. However, those apparently drowned may be the victims of shock, syncope, apoplexy, heart-strain due to overexertion, or nephritic coma. Fortunately syncope often prolongs the time the individual may be under water and be resuscitated. It has long been known that strong men are less often revived than those who are apparently weaker. The explanation seems to be that the weaker are more likely to faint, so that the lungs are not filled with water and a low grade of respiration continues for some time, during which there is more or less interchange between the remnant of air within the lungs and the circulation. Some-

times strong men will collapse from shock or fright, more especially in impending death from cramp. At any rate, syncope increases the individual's chances of recovery after submersion.

Artificial rhythmic compression of the heart, in addition to artificial respiration, greatly aids in the resuscitation of those apparently drowned.

The various methods of artificial respiration, notably those of Marshall Hall, Sylvester, Howard, and Schäfer, all have their advocates. Of these, the author prefers the method of Professor Schäfer. In this method the patient is placed in a prone position. Then the physician, astride the patient, exerts pressure on either side of the lower ribs. The pressure should be firm, continued for three seconds, then quickly relaxed. This should be repeated at the rate of twelve times per minute. The artificial respiration should be timed to correspond with any attempts at natural respiration.

When available, the pulmotor takes precedence over all the older forms of artificial respiration. With it, as with the other forms of artificial respiration, the use of fresh, pure air is important, and the addition of oxygen is advantageous. (See *Resuscitation.*)

It is important that the body heat should be maintained or brought up to the normal. But nothing should interfere with the early induction of artificial respiration. A minute lost at this time may mean the loss of the patient's life. While artificial respiration is being conducted, the patient should be kept warm. The body should be dried and friction may be advantageously employed over the surface of the body, especially from the extremities toward the heart.

How long after submersion may the patient be rescued? How long should efforts to resuscitate be continued? All sorts of reports may be found in the literature. It is a pretty good general rule to begin the efforts at the earliest minute possible and to continue so long as there is no positive evidence of the actual death of the individual. The pallid cases usually do not respond to artificial respiration after the heart has really stopped. At any rate, artificial respiration should be continued so long as there is the faintest action of the heart obtainable by cardiac massage. Deep pressure over the abdominal aorta, just below the ensiform cartilage, may reveal pulsations when they cannot be detected elsewhere. The recommendation that artificial respiration should be continued from one to two hours is more arbitrary than rational. Should postmortem rigidity ensue, as it sometimes does within a few minutes, further efforts at resuscitation will be futile.

1. Begin artificial respiration at once, being sure that the air actually reaches and leaves the lungs. Artificial teeth or other possible impediments to respiration should be removed. Oftentimes the stomach is full and may be emptied by pressure judiciously applied so as to avoid the possibility of rupture of the stomach.

2. Stimulate the heart by warmth, friction, and possibly the injection of adrenalin in saline solution. Employ cardiac massage if needed.

3. If the patient is removed to a hospital or to different quarters, maintain respiration and the action of the heart during the transfer.

4. Use oxygen if available.

5. Do not interrupt the efforts at artificial respiration so long as there is the possibility that the individual is still alive. Many of the remarkable reports of recovery after prolonged effort are undoubtedly true. In this connection, we would warn against the old method of testing the eye with ether for evidence of inflammatory reaction, for this is both dangerous and thoroughly unreliable.

There is always some residual air remaining in the lungs. This may be detected, both over the surface and upon section of the lung, in postmortem examinations. Some of the pulmonary alveoli rupture, permitting interstitial extravasation of the fluid. The right lung usually contains more fluid than the left, the lower lobes more than the upper, and the central portions of the lungs more than the edges. The lungs are distended, presenting the characteristic balloon-like inflation, to which much diagnostic import has been attached. This is due to the filling up of part of the pulmonary tissue with water, while the collapse of the lungs is prevented by the interstitial infiltration of the fluid.

The changes that occur in the submerged body vary somewhat with the temperature of the water, whether it is running or still water, and upon its purity. Nevertheless, the examination of the body will enable one to form an opinion as to the length of time the body has been submerged. Thus, usually within twenty-four hours the epidermis of the tips of the fingers will begin to show changes due to the imbibition of water. The epidermis becomes pale, swollen, and wrinkled. Within two to four days the epidermis of the thenar and hypothenar eminences show similar changes to those that earlier appear in the tips of the fingers, and still later these changes spread, to appear within a few days over the entire palm of the hand. Within a few weeks the epidermis becomes markedly swollen, wrinkled, pale, and more or less detached. The epidermis and nails separate from the hand like a glove, exposing the underlying parts that now present the appearance of a gracile and well cared for hand. This appearance tends to mislead the judgment as to the social position and occupation of the individual. A similar glove-like detachment of the epidermis occurs in scalding and burning and through putrefaction. After prolonged submersion an unctuous covering is formed over the exposed parts of the body through the growth of a fungus. This appears first and is most marked over the more angular portions of the exposed body, especially such regions as the popliteal spaces and about the hands and feet. Should there be no such fungus on the body, it has probably not been in the water more than six or seven days. The growth of the fungus occurs at a temperature as low as 8° C. or even lower, but is slower in winter than in summer. Within two weeks the body is pretty well covered, the coating reaching a thickness of one to one and a half centimeters. By the end of a month the body is so completely covered by a thick coating that the general form is pretty well obscured, and the fungus appears discolored. The fungus appears filamentous under water. At the end of two weeks it gives the impression of wet cotton when the body is removed from the water. At the end of a month it becomes so contaminated as to present more the appearance of ordinary mire.

GEORGE E. MALSBARY.

**Drowsiness.**—See *Sleep, Disorders of.*

**Drug Eruptions.**—See *Dermatitis Medicamentosa.*

**Drug Habits.**—See *Alcoholic and Drug Intoxication.*

**Dublin, N. H.**—The most elevated village in New Hampshire (between 1,500 and 1,600 feet), is situated in the southwestern part of the State, 85 miles from Boston. Although not in the White Mountain district, Dublin has a greater elevation than any resort in that region, Bethlehem being the highest with an elevation of 1,459 feet. The town lies at the base of Mount Monadnock, 3,186 feet, near which is Lake Monadnock, and possesses unusual beauty of scenery. The roads, which are good, afford charming drives. The characteristics of the climate are the purity of the air and its tonic qualities. Below are the meteorological data so far as they are obtainable:

Meteorological Data of Dublin, New Hampshire.
(Temperatures in Fahrenheit scale.)

| 1893. | Maximum. | Minimum. | Mean of maximum and minimum. | Clear days. | Partly cloudy. |
|---|---|---|---|---|---|
| January | 45° | —14° | 15.5° | 13 | 3 |
| February | 45 | —10 | 17.5 | 13 | 5 |
| March | 53 | 1 | 27.0 | 11 | 9 |
| April | 61 | 17 | 39.0 | 12 | 5 |
| May | 85 | 32 | 58.5 | 14 | 5 |
| June | 86 | 44 | 75.0 | 10 | 7 |
| July | 84 | 46 | 65.0 | 18 | 9 |
| August | 86 | 47 | 66.5 | 16 | 9 |
| September | 72 | 37 | 54.5 | 12 | 6 |
| October | 70 | 23 | 46.5 | 10 | 3 |
| November | 58 | 11 | 34.5 | 10 | 5 |
| December | 51 | — 8 | 21.5 | 12 | 7 |

There is no record of relative humidity, but it probably does not differ very much from that of Bethlehem, which for July, August, and the first half of September for five years was 65.8 per cent. There are frequent strong west winds, but fogs are rare.

The usual summer range of temperature is from 68° to 75° F.; the maximum, exceeding 80°, is reached perhaps once or twice in the summer. The nights are always cool. The dryness of the air is marked.

There is one first-class hotel, and there are several boarding-houses, though the predominant mode of life is the cottage one; and comfortable, even luxurious houses can be rented. There are Unitarian and Episcopal churches, also a good public library. Dublin has now become an established summer resort, and possesses many fine private residences.

The attractions are the charming excursions in the country about, mountain climbing, driving, boating, bathing, fishing, tennis, golf, and the usual social life of a large summer community. The water supply is excellent and the drainage good. The soil is sufficiently porous to absorb quickly the water after rain. The subsoil is a mixture of clay and gravel. From its elevation, from the purity and dryness of the air as well as its tonic qualities, the climate of Dublin is a favorable one for pulmonary tuberculosis. The climate is recommended also for bronchitis, gout, rheumatism, neurasthenia, insomnia, cardiac indolence, and general depression of health. From personal experience the writer can testify to the purity and exhilarating quality of the air and the beauty and charm of the scenery. In the early autumn, when the leaves are coloring and the air is crisp, outdoor life is a delight, and riding or walking along country roads affords a constant succession of delightful views.

Edward O. Otis.

**Duboisia.**—The leaves of *Duboisia myoporoides* R. Br. (fam. *Solanaceæ*). This is a large shrub or small tree of Australia and some neighboring islands. As the drug occurs in commerce, it is usually broken up into a mass of fragments, mostly from an eighth to a half inch in length. These are brownish, smooth, and slightly shining. When entire, the leaves are from three to four inches in length by from half an inch to one inch in breadth, and are lanceolate, narrowed toward both ends, and have an entire margin. They have a very slight narcotic odor and a bitter taste. They are not very largely used, but there is a small steady demand for them, for the same uses as those of stramonium or belladonna. The alkaloids are accompanied by some resinous matter, and the accounts of them have been very contradictory. It is now generally recognized that "*duboisine*," the principal one, is identical with *hyoscyamine* in composition and action. It has been used as a substitute for atropine in eye practice, and the drug is the equivalent, in action, use, and dosage, of belladonna.

*D. hopwoodii* von Mueller, or "pituri," of Australia, contains an alkaloid, *piturine* ($C_{12}H_{16}N_2$), closely resembling nicotine. The powdered leaf is smoked like tobacco, and is said to be stimulating and supporting, like coca, kola, and other drugs.

Henry H. Rusby.

**DuBois, Abram.**—Born at Red Hook, Dutchess County, New York, April 5, 1810. In 1832 he entered the College of Physicians and Surgeons, New York City, and received the degree of Doctor of Medicine from that institution in 1835. Very soon after graduation he sailed from New York for France, and remained in Paris nearly eighteen months. He was diligent in his attendance upon the clinics of Louis, Andral, and Chomel, in medicine, and Velpeau and Lisfranc, in surgery. He also frequented the clinics of Sichel, who was at that period the leading specialist in Paris in diseases of the eye. Upon his return to New York, in December, 1836, he was appointed an assistant resident physician at Bellevue Almshouse Hospital. Shortly after he entered upon his duties in this institution, Dr. Benjamin Ogden, who was his superior officer, was appointed Resident Physician of Bloomingdale Asylum for the Insane. At the same time Dr. Ogden was permitted to retain his position at Bellevue Hospital—presumably in order that he might exercise some degree of supervision over the two assistant physicians (Dr. DuBois and Dr. D. L. Eigenbrodt), who were now, to all intents and purposes, left in sole charge of the medical wards of the hospital. This responsibility was very soon put to the test by the occurrence, in epidemic form, of a virulent type of fever which by some was termed "ship fever" or "jail fever," while by others it was called "typhoid fever." The wards of the hospital were soon filled with patients affected with the disease, and only a short time elapsed before Dr. DuBois himself contracted the malady. Recovery took place only after a prolonged convalescence. The Commissioners of the Almshouse, recognizing the faithful and courageous service which Dr. DuBois and his associate had rendered to the hospital entrusted to their professional care, presented each, upon the expiration of their term of service, with a valuable case of surgical instruments, accompanied by appropriate resolutions.

After leaving Bellevue Hospital Dr. DuBois began to turn his attention to the treatment of eye diseases. His friend and former preceptor, Dr. John Kearny Rodgers, was at that time one of the attending surgeons of the New York Eye Infirmary and Dr. DuBois assisted him in his most important operations. In 1843 he was himself made an attending surgeon of the institution, and from that time to the day of his death—a period of forty-eight years—he never ceased to take an active interest in its welfare. A. H. B.

**DuBois-Reymond, Emil.**—Born in Berlin, Prussia, November 7, 1818. He studied medicine in the University of his native city, largely under the guiding influence of Johannes Mueller, who was then making Berlin famous as a school for anatomy and physiology. In 1840 Mueller made him his assistant in physiology, and, "as a starting-point for an inquiry, put into his hands the essay which the Italian, Carlo Matteuci, had just published on the electric phenomena of animals. This determined the work of DuBois-Reymond's life. He chose, as the subject of his graduation thesis, Electric Fishes,' and so commenced a long series of investigations on animal electricity, by which he enriched science and made for himself a

name." (Encycl. Brit., Eleventh edition.) In 1858, upon the death of Mueller, the chair of anatomy and physiology was divided and that of physiology was given to DuBois-Reymond. "For many years he and his friend H. vonHelmholtz, who like him had been a pupil of Johannes Mueller, were prominent men in the German capital. . . . Both, from time to time as opportunity offered, stepped out of the narrow limits of the professional chair and gave the world their thoughts concerning things on which they could not well dwell in the lecture room. . . . They (DuBois-Reymond's discourses) are marked not only by a charm of style, but by a breadth of view such as might be expected from Johannes Mueller's pupil and friend." He died in Berlin, November 26, 1896.

DuBois-Reymond's most important published writing bears the title "Researches on Animal Electricity." The different parts of this work were issued between the years 1848 and 1884. A. H. B.

**Duchenne, G. B.**—Duchenne, called usually Duchenne de Boulogne, was born at Boulogne-sur-Mer, France, on September 17, 1806. He studied medicine in Paris, and began the practice of his profession in his native city in 1831. His first investigations into the healing powers of electricity were made in 1835. In 1842 he left Boulogne and established his home in Paris; and from then until the time of his death he got along without accepting (or even applying for) a single official position as teacher or as surgeon or physician of a hospital. On the other hand, he utilized—so far as he was permitted to do so—the available material existing in all the Paris hospitals and clinics. Notwithstanding all the obstacles which he encountered he managed to accumulate in great abundance the materials out of which he constructed modern electrodiagnosis and electrotherapeutics, and won for himself the title of creator of this branch of medical science. He died in Paris September 17, 1875.

Duchenne's great work is entitled: De l'électrisation localisée et de son application à la pathologie et à la thérapeutique," third edition, Paris, 1872.

A. H. B.

**Ductus Arteriosus.**—*Synonyms*: Ductus arteriosus Botalli, Ductus Botalli, Arterial canal, Arterial duct.

This atypical blood-vessel represents the remains of part of the fourth left arterial arch of the early embryo, which functionates until birth to carry part of the blood from the pulmonary artery to the aorta, but immediately after birth it becomes occluded, and eventually it is completely obliterated. At the time of birth it is as large as or even larger than the main divisions of the pulmonary artery, being from five to seven millimeters in diameter, and from four to twenty millimeters long, generally nine to twelve millimeters (Gérard). It arises from the pulmonary artery at the bifurcation, or a little to the left of this point, and passes first horizontally, then slightly downward, nearly paralleling the arch of the aorta, which it enters opposite to and a trifle below the origin of the left subclavian artery, and a short distance above the first intercostals. Its most important relations are to the pericardium, immediately outside of which it begins, passing in front of the left bronchus, and being encircled at its entrance to the aorta by the left recurrent laryngeal nerve. Histologically it presents the usual features of arteries of this size, but it is unusually poor in elastic fibers, a large proportion of which run longitudinally in bundles, and the muscular coat is not well developed. It is not strong, being readily torn, and will withstand but little more than the normal fetal blood pressure without abnormal dilatation and tearing of its coats (Roeder).

As soon as the new-born infant begins to breathe, the duct becomes at once occluded, and later the lumen is entirely obliterated. The mechanism by which the first occlusion is accomplished is not yet fully determined. Among the most reasonable of the many hypotheses advanced are: (1) That fibrous bands which are connected with the diaphragm pass around the duct, and occlude it when the dome of the diaphragm is first drawn down in respiration (Forbes). (2) That the changes in relative position

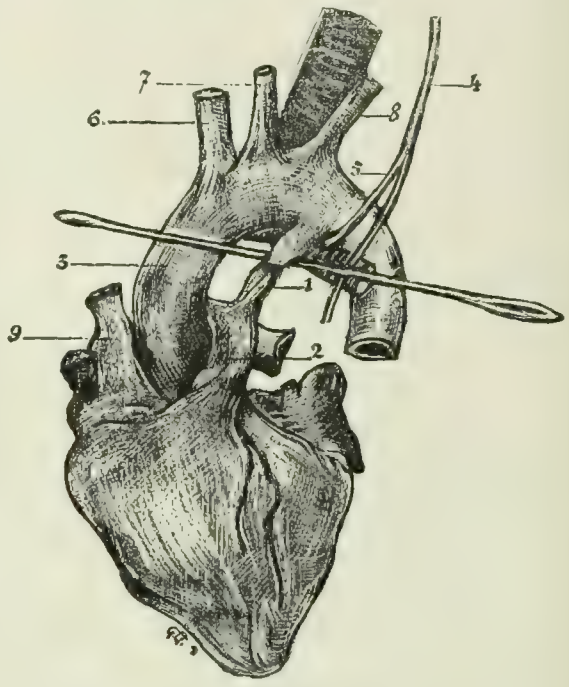



Fig. 1786.—The Ductus Arteriosus, after Dissection of the Vessels at the Base. (Gérard.) 1, Ductus arteriosus; 2, pulmonary artery; 3, aorta; 4, pneumogastric nerve; 5, recurrent nerve; 6, innominate artery; 7, left common carotid; 8, left subclavicular artery; 9, superior vena cava.

of the great vessels and the thoracic viscera, that result from the filling of the lungs, draw out the duct until its walls are in apposition, and thus occlude its lumen (Schanz, Gérard, and others). (3) That on account of the acute angle at which the duct enters the aorta a valve-like fold is formed which prevents blood from entering from the aortic end, although leaving the passage free for the entrance of blood from the pulmonary system when, as in the fetus, the pressure is higher there than in the aorta (Zuntz, Strassmann). The last theory seems to have received the best support, although Kirstein holds that the contraction of the walls of the duct is a factor of some importance. When the circulation of blood through the duct stops, proliferative changes in the fibrous elements of the duct, especially in the intima, lead to its obliteration and conversion into a fibrous cord, the *ligamentum arteriosum*, which persists in the adult. The channel does not become entirely impermeable until some time after birth, usually between the thirtieth and fortieth days, although often much earlier; a minute passage may remain for years.

Pathology.—*Congenital Anomalies.*—Almost every abnormal developmental condition about the heart and great vessels may be accompanied by abnormalities in the ductus arteriosus, such as: Absence, abnormal shortness, duplication, abnormal origin or insertion, premature occlusion. In most cases these are merely an accompaniment of the more important deformity of the heart and vessels.

*Persistent Patency.*—Whenever there exist congenital anomalies in the heart and great vessels that are not incompatible with life, the duct may fail to close, because the normal changes in the relation of aortic and pulmonic blood pressure do not take place at the time of birth. In congenital pulmonary stenosis the pulmonary circulation is largely carried on by blood reaching the pulmonary arteries through the duct; and in congenital aortic stenosis the pulmonary artery supplies blood for the general circulation through the duct, as in the fetus. Primary persistence of the duct without other abnormalities is an extremely rare condition, constituting but about four per cent. of the recorded cases of congenital

Fig. 1787.—Aneurysm of the Ductus Arteriosus. (Gérard.) 1, Aneurysmal enlargement; 2, pulmonary artery; 3, aorta; 4, 5, right and left branches of the pulmonary artery; 6, vena cava superior; 7, vena cava inferior.

diseases of the heart and vessels. In 1898 Vierordt could collect but 26 cases, and in 1907 I was able to add 15 to this list: of the 33 cases in which the sex was recorded there were 12 males and 21 females. The chief predisposing cause seems to be respiratory difficulties in early life which keep the pulmonary blood pressure high and prevent occlusion; premature birth, abnormal insertion of the duct, abnormally large caliber, and simple failure of the occluding apparatus may also be responsible in some cases. Congenital syphilis does not seem to have been observed as a cause, but paternal alcoholism is frequently recorded. It is also possible for a duct that has been properly occluded, but only imperfectly obliterated, to reopen again under the influence of the aortic pressure, possibly after several years. Four anatomical forms of patent duct were recognized by Gerhardt: (1) Abnormal shortness; simply an opening between the aorta and the pulmonary artery; (2) funnel-shaped, with the wide end toward the aorta; (3) cylindrical form; (4) aneurysmal dilatation. Frequently the pulmonary opening, which is usually smaller than the aortic, is surrounded by fibrous folds or a ring. The condition has been observed at all ages up to sixty-six years, and unless the size of the opening is large the results are not necessarily serious, although a greater or lesser degree of incapacity usually results; however, evidences of severe cardiac incompetence have been present in many of the cases, and death may result from this cause. Spontaneous healing by occlusion of the pulmonary opening may take place. The chief diagnostic features are: A systolic thrill, palpable best in the left second and third intercostal spaces, following the apex beat and continuing into the diastole; a murmur of corresponding duration and location, transmitted into the carotids and also heard posteriorly in the left superior interscapular region; a band of dulness along the left side of the sternum as high as the second rib, due to dilatation of the pulmonary artery, and the presence of a corresponding shadow in radiographic pictures. Cyanosis is less prominent than in most other congenital cardiac abnormalities, and often it is absent. Pressure has been produced on the left recurrent nerve.

*Thrombosis* of the duct is not an essential part of its obliteration, as once thought, but is a relatively uncommon occurrence. It is occasionally present in infants dying from septic conditions, and adults with a patent ductus arteriosus may show vegetations in the duct secondary to extension from an acute endocarditis.

*Aneurysm* of the duct has been described in about a dozen cases, usually in infants a few days old. These aneurysms are occluded by thrombi, and represent what is probably not an extremely uncommon condition. Two cases of rupture of the duct in the newborn have been described by Roeder, and attributed to high pressure during labor, or from other causes.

H. Gideon Wells.

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**Dudley, Benjamin Winslow.**—Born in Spottsylvania County, Va., April 12, 1785, and brought by his parents, while he was still an infant, to Lexington, Kentucky. He received the degree of Doctor of Medicine from the University of Pennsylvania, in 1806. Upon his return to Lexington he began to engage in the practice of his profession, but soon discovered that he was not yet sufficiently well prepared for the satisfactory performance of the duties of a practitioner of medicine. His desire was to go into the hospitals and follow the great teachers of Europe, but he lacked the necessary funds. "To get these he made a venture in trade. He purchased a flat-boat, loaded it with produce, headed it for New Orleans, and floated down the Kentucky, the Ohio, and the Mississippi rivers to the desired port. He invested the proceeds of his cargo in flour. This he billed to Gibraltar, which he reached some time in 1810; there, and at Lisbon, he disposed of it at a large advance." (Yandell.) With the financial means which he had thus cleverly secured, he visited first Paris and next London, remaining three years in the former city and nearly one year in the latter. He lost no opportunity of listening to the teachings of men like Baron Larrey and Abernethy and of witnessing the operations performed by such surgeons as Sir Astley Cooper. In 1814 he returned to Lexington and resumed practice with great eagerness. The knowledge of anatomy and surgery which he had gained abroad now stood him in good stead, and very soon he had his hands

full of practice. In 1817 the trustees of Transylvania University organized a school of medicine and made Dr. Dudley head of the new department; it being understood that he was to fill the chairs of anatomy and of surgery. In the course of time he acquired great reputation for his skill in certain kinds of operative work. "Dr. Dudley"—to quote again the words of Dr. Yandell—"stands the confessed leader of American lithotomists, heading the list with 225 cases, losing only six patients, and having had occasion to repeat the operation in but one instance. This success was so great that in England he was declared to be *the* lithotomist of the nineteenth century." Dr. Dudley was also a valuable contributor to our knowledge of the proper use of the trephine in injuries of the cranium, and of the curative effect, upon fungus cerebri, of gentle and sustained pressure when made by means of a dry sponge held firmly in place by a roller bandage.

Dr. Dudley wrote but little. His first article, which was not published until 1828, related to injuries of the head. Then followed other articles on hydrocele, on bandages, on fractures, and on the treatment of calculous diseases. His death occurred January 20, 1870. A. H. B.

**Duhring, Louis Adolphus.**—Born in Philadelphia, December 23, 1845. After graduation from the Medical Department of the University of Pennsylvania in 1867 and service as intern in the Philadelphia Hospital he studied dermatology in the clinics of Paris, London, and Vienna. On returning to Philadelphia in 1870 he established a dispensary for the study and treatment of diseases of the skin, serving first as attending physician for a number of years and later as consultant. In 1871 he was appointed clinical lecturer on diseases of the skin, in 1876 professor, and in 1911 emeritus professor at the University of Pennsylvania. He died May 7, 1913.

Dr. Duhring devoted all his professional life to dermatology, being a frequent contributor to the periodical literature of that branch of medicine. His most important works were: "An Atlas of Skin Diseases," 1876; "A Practical Treatise on Diseases of the Skin," 1877, translated also into French, Italian, and Russian; and "Text-book of Cutaneous Medicine," 1898. He was one of the founders of the American Dermatological Association and was an honorary or corresponding member of most of the European dermatological societies. Dermatitis herpetiformis, of which he gave a classical description, has been called "Duhring's disease."

T. L. S.

**Dujardin-Beaumetz, George Saintfort Octave.**—Born in Barcelona, Spain, in 1833. He studied medicine in Paris, and received the degree of Doctor of Medicine in 1862. From 1876 to 1882 he was Physician-in-Chief at the St. Antoine Hospital, and gave regular courses of clinical lectures which were frequented by large numbers of students. From 1882 to the time of his death he held the same position at the Cochin Hospital. During the last two years of his life he was Editor-in-Chief of the *Bulletin général de thérapeutique*. He died February 16, 1895.

Dujardin-Beaumetz's best work was done in three different departments of medicine: in that of nervous diseases, in hygiene, and in the management of hospitals, particularly those of Paris. Of his published writings the following deserve to receive special mention: "Dictionnaire de thérapeutique, de matière médicale, etc.," Paris, 1882; "Leçons de clinique thérapeutique, professées à l'hôpital St. Antoine, etc.," Paris, 1878–1881; "Les troubles de l'appareil oculaire dans les maladies de la moëlle"; "L'emploi du phosphore en médecine"; and "Recherches expérimentales sur la puissance toxique des alcohols," Paris, 1879. A. H. B

**Dulcamara.**—Bittersweet. The young branches of *Solanum dulcamara* L. (fam. *Solanaceæ*). This is a weak, straggling, half-woody, hairy perennial, its stems often six or eight feet long and reclining upon shrubbery. It has alternate leaves, many of them pinnately three to five lobed or parted, pretty blue star-shaped flowers, in small cymes, and bright scarlet, shining, oval fruits, about half as large as cranberries, and somewhat poisonous. It is a native of Europe and Asia, and thoroughly naturalized in this country, where it is abundant along streams and ditches and in wet pastures. The Pharmacopœia formerly described the drug as follows: "About five millimeters or less thick, cylindrical, somewhat angular, longitudinally striate, more or less warty, usually hollow in the center, cut into short sections. The thin bark is externally pale greenish or light greenish brown, marked with alternate leaf scars, and internally green, the greenish or yellowish wood forming one or two concentric rings. Odor slight, taste bitter, afterward sweet."

*Composition.*—In spite of a great deal of study, our knowledge of the composition of dulcamara is very uncertain. Its bitter and sweet taste are due to two glucosides, *dulcamarin*, similar to saponin, and *picroglycion*, besides which there exists a body called *solanin* or *solanine*. The latter is the most indefinite of all the constituents. It is said to decompose after the manner of a glucoside, with which it is classed by Merck, yet it contains nitrogen and yields salts, like the alkaloids. It is not even known if it be identical with the solanine of other species of the genus. For a full account of solanin see article on Potato, under *Poisonous Plants*. Wax, gum, starch, and resin are also present.

Solanin exists in such very small amount as to contribute little activity to the drug, which has been used in the most indefinite way as an alterative and tonic.

Its close relation to a number of deleterious solanin-bearing plants has made its reputation suspicious, but the records of injury, from the green plant even, are very few; from the dried, almost none. A large quantity of a decoction made from the stems has been taken, followed only by transient numbness, dryness of the mouth, and paralysis of the tongue. In medicinal doses it can scarcely be said to have any physiological action. The amount of solanin, especially in old stalks, is very small. Given in copious hot decoction, bittersweet is probably diaphoretic and diuretic, and is still occasionally used in chronic rheumatism, as well as in psoriasis and some other chronic skin diseases. Dose, ʒi. ad ʒ iv. (4.0–16.0). A fluid extract is made, but an extemporaneous decoction is probably a better form.

H. H. Rusby.

**Dulcin** is paraphenetol carbamide, $C_2H_5O.C_6H_4$-$NH.CO.NH_2$, a urea derivative of phenetidin; it is also known as *sucrol*. It occurs in colorless crystals and is about 200 times sweeter than sugar; it is used to render more palatable certain pharmaceutical preparations. It has also been suggested as a substitute for sugar in the diet of diabetic patients. Its insolubility is its chief disadvantage; but, on the other hand, its continued use is not so unpleasant as is that of saccharin. Dulcin is an interesting example of the difference between the methyl and ethyl groups in certain compounds, the methyl derivative corresponding to dulcin being without taste. The dose is one or two grains; but as much as half a dram may be taken during twenty-four hours. R. J. E. Scott.

**Dumas, Charles Louis.**—Born at Lyons, France, February 8, 1765. He began the study of medicine at Montpellier when he was only seventeen years of age, two of the most distinguished men of that school—Barthez and Grimand—being his instructors. He received the doctor's cap in 1785, and then continued his medical studies at Montpellier during the following two years. In 1787 he went to Paris and soon succeeded in winning the friendship of Vicq-d'Azyr, the distinguished anatomist. In 1792 he returned to his home in Lyons, and for a short time he acted as substitute physician at Hôtel-Dieu, the great hospital of that city; but, on the termination of the siege, he was obliged to flee for his life. He took refuge in Paris, then served for a short time as *officier de santé* at Toulon, and finally joined the French army in Italy. In 1795, when the medical school at Montpellier was reorganized, Dumas was chosen Professor of Anatomy and Physiology. In 1798 he was made president of the school, and, still later, dean of the Medical Faculty of that city. He died March 28, 1813, at the early age of forty-seven, and at the height of his fame.

The medical school of Montpellier claims, with entire justice, that Dumas contributed very largely to the maintenance of its glory, and that his profound erudition, his power to reason clearly, and his firmness of character, made him a worthy successor of Barthez.

Of the different essays and treatises which Dumas has handed down to posterity the following deserve to receive special mention: "Système méthodique de nomenclature et de classification des muscles du corps humain," Montpellier, 1797; "Principes de physiologie, ou Introduction à la science expérimentale, philosophique et médicale de l'homme vivant," four volumes, Paris, 1800–1803 (the second edition, published at Montpellier in 1806, is said to be a more perfect work); and "Doctrine générale des maladies chroniques, pour servir de fondement à la connaissance théorique et pratique de ces maladies," Montpellier, 1812. A. H. B.

**Dunglison, Robley.**—Born in Keswick, England, January 4, 1798. He received the degree of M.D. in London in 1819, and from the University of Erlangen, Germany, in 1823. In 1824, at the invitation of Thomas Jefferson, he came to the United States, and, from that year till 1833, he was Professor of Medicine in the University of Virginia. In 1836 he was chosen Professor of the Institutes of Medicine in Jefferson Medical College, Philadelphia, and he held this position for over thirty years. Stone, in his "Biography of Eminent American Physicians and Surgeons," says that the extraordinary success of this institution was largely due to the attractive course of lectures which he gave and to the remarkable tact and practical sagacity with which he, as Dean of the Faculty, administered its affairs. In 1825 he received the degree of LL.D. from Yale. His death occurred April 1, 1869.

Dr. Dunglison's contributions to medical literature were very numerous and of a high order of merit. His Dictionary of Medical Science and Literature, which was first published in 1833, and of which twenty-three editions have been issued, contributed, more than did any of his other books, to make him famous throughout the English-speaking medical world. A. H. B.

**Duodeno-cholecystostomy.**—See *Gall-bladder.*

**Dupuytren's Contraction.**—See under *Hands and Fingers, Deformities of.*

**Dupuytren, Guillaume.**—Born at Pierre Buffiere, Department of Haute Vienne, France, October 6, 1777. He studied medicine at the École de Médecine, of Paris, and was appointed (after a competitive examination) prosector when he was only eighteen years old. He devoted himself chiefly, at this period of his studies, to pathological anatomy. In 1803 he was appointed Assistant Surgeon at the Hôtel-Dieu, and in 1811 Professor of Operative Surgery. In 1815 he was chosen Professor of Clinical Surgery, and was made Surgeon-in-Chief at the Hôtel-Dieu.

He is said to have amassed a fortune of 4,000,000 francs ($800,000) from the practice of his profession. At his death he left 200,000 francs to the Faculté de Médecine for the establishment of a chair of pathological anatomy. The State, however, established this chair, so the sum which he left for this purpose was diverted to the foundation of the Musée Dupuytren of Pathological Anatomy.

Dupuytren was a tireless worker and was possessed of astonishing energy. He had an enormous private practice and in addition visited the Hôtel-Dieu twice a day, performing one or more operations

Fig. 1788.—Guillaume Dupuytren.

at each visit, and lectured several times a week to throngs of students and of surgeons from all parts of the world who were drawn to Paris by the fame of his teaching.

Many and great were his contributions to the science and art of surgery. He established a classification of burns, described echinococcus cysts of bone, noted the presence of rice bodies in enlarged tendinous bursæ, described senile gangrene under the title of "gangrène symptomatique de l'artérite"; he called attention to the danger attendant upon entrance of air into the large veins; he described traumatic aneurysm, false aneurysms, and varicose aneurysms, and was the first surgeon in France to ligate the larger arteries; he distinguished nervous delirium from delirium tremens; established the differential diagnosis of fracture and dislocation of the humerus, and wrote on fractures and the formation of callus; described the contraction of the palmar fascia called by his name; established the operation of resection of the lower jaw; devised an effective operation for ingrown toe-nail; etc.

He wrote little himself, but his lectures were taken down and published by a society of physicians under the title: "Leçons orales de clinique chirurgicale faites à l'Hôtel-Dieu de Paris," in four volumes, Paris, 1830-1834. These were translated into German, Italian, English, and Danish, and a second edition in six volumes was published in 1839. He also published a "Traité théorique et pratique des blessures par armes de guerre," Paris, 1834; and "Mémoire sur une manière nouvelle de pratiquer l'opération de la pierre," Paris, 1836. T. L. S.

**Durand-Fardel, Charles L. M.**—Born in Paris, France, in 1815. After he had completed the regular course of medical studies, he undertook the duties of Inspector of Mineral Springs for the district lying between Paris and Vichy. Between 1839 and 1848 he published a number of papers on topics relating to the physiology and pathology of the brain. After the latter date his published writings dealt chiefly with balneological topics, such as: "Des eaux de Vichy, etc.," Paris, 1851; "Traitè therapeutique des eaux minérales de France at dè l'étranger, etc.," 1857; and (in association with LeBret, Lefort and François) the "Dictionnaire général des eaux minérales et d'hydrologie médicale," 1860. He also published the "Traité pratique des maladies chroniques," two volumes, Paris, 1868; and "Traité pratique des maladies des vieillards" second edition, Paris, 1873. The latter is his best known work and the one upon which his fame largely rests. For a period of forty years he was the official physician of the Baths of Vichy. He died March 19, 1899.

A. H. B.

**Durango.**—See *Mexico.*

**Duret, Louis.**—Born at Bauget-la-Ville, France, in 1527. From his earliest youth he cultivated a knowledge of Greek, Latin, and Arabic, and ultimately he acquired marvelous skill in interpreting the writing of some of the earlier authors of medical treatises and in correcting errors which had crept into their works through the carelessness or ignorance of copyists. Shortly after he had received the degree of Doctor from the Paris Faculty of Medicine (September 12, 1552) he began giving instruction in that branch of science. He was chosen the regular medical adviser of Charles IX. and Henry III., kings of France; and from 1568 to 1586 he held the position of Professor in the College of France. He died on January 22, 1586, at the comparatively early age of fifty-nine.

It is said of Duret that he possessed an extraordinary memory, being able to repeat, on the spur of the moment, whole sections from the writings of Hippocrates. He was a great admirer of the latter's teachings. He had scant love for the "polypharmacy" of the Arabians, nor could he tolerate the foolish subtleties of the medical teaching of his own time. As his lectures were attended by large numbers of eager auditors, one can readily appreciate that Duret's influence in disseminating sound medical learning must have been very great. Being a very close and accurate observer and having a large clientèle of patients, he was soon able to add his own personal experience to the teachings of Hippocrates. In one of the cases that came under his care he adopted a course of treatment that proved entirely successful; and yet a modern physician, basing his judgment merely upon the very scanty facts which have been handed down to us, would agree with Dezeimeris in pronouncing the measures taken as somewhat audacious. The patient, an adult male, had been suffering for a period of about one year, from a severe pain in the head, for which he had been unable to obtain any relief. Duret first had all the hair removed from the man's head by shaving, and then he applied to the entire scalp a large poultice. After a short time the poultice was removed, and it was then found that there was one spot where the scalp was less moist (*plus desséché*) than at any other point. Duret, being satisfied that the "morbific humor" must be located in the deeper part of the head immediately beneath this spot, applied the trephine to the corresponding part of the external table of the skull, and had the satisfaction of witnessing a great outflow of pus similar, both in consistency and in color, to honey, as soon as the instrument had penetrated as far as the diploë. The pain disappeared almost at once and complete recovery followed.

Duret wrote a commentary upon the first six sections of the *Aphorisms of Hippocrates* and also a *Treatise on the Diseases of Women*, but both of these books have been lost. Of the three works which were published after his death the most important is unquestionably that which bears the following title: "Interpretationes et enarrationes in magni Hippocratis coacas prænotiones," Paris, 1588 (a better edition was published at Leyden in 1784).

A. H. B.

**Duverney, Jean Guichard.**—Celebrated anatomist of the seventeenth century, who counted among his pupils such men as Riolan, Winslow, Sénac and Petit. Born at Feurs, France, August 5, 1648. He studied medicine at Avignon, and received his doctor's cap in 1667, before he had reached his twentieth year. From the very first he manifested, in his studies, a strong preference for anatomy, and during his life in Paris, to which place he had gone shortly after he received the doctor's degree, he continued with great ardor, almost up to the very day of his death, the prosecution of his anatomical researches. He rapidly gained in favor as a teacher of this branch of medical science, and in 1674 was elected a member of the *Académie royale des sciences.* Five years later, he was made Professor of Anatomy at the *Jardin-du-Roi.* Shortly before his death he began, in conjunction with his pupil Winslow, the preparation of a second edition of his treatise on the organ of hearing, but he died before the work was finished. His death occurred September 10, 1730—that is, when he was eighty-two years old.

Duverney's name is perpetuated in the history of medicine by the following anatomical and surgical terms: Duverney's gland, Duverney's foramen, and Duverney's fracture. During his lifetime Duverney published only the following work: "Traité de l'organe de l'ouie, contenant la structure, les usages, et toutes les maladies de l'oreille," Paris, 1683. After his death the following treatises were also published: "Traité des maladies des os," Paris, 1751, two volumes; and "Oeuvres anatomiques," Paris, 1761, two volumes.

A. H. B.

**Dwarfs.**—See *Cretinism and Nanism.*

**Dynamometer.**—In general, an instrument to measure or test the strength of the grasp of the hand. Various forms of instrument have been devised, that one most in clinical use being the French instrument here illustrated. (Fig. 1789.) This consists of two bent steel rings between which a geared register is arranged to individually record the pressure exerted in pounds or kilograms. It is fairly well adapted for

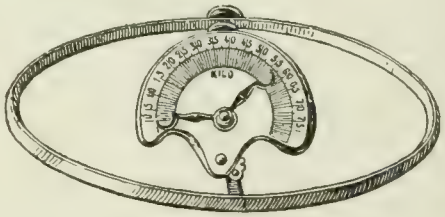

Fig. 1789.—The Simplest Form of Dynamometer.

ordinary clinical purposes, but has a number of defects which will be discussed. One of the chief defects so far as its being reliable instrument for recording constantly, so as to make it valuable in the study of physiological problems of muscular fatigue is that it records only central pressure and any slight shift in the grasp to one or the other side of the exact center

invalidates the readings. A better instrument is that devised by Chérin and Verdin (Fig. 1790). Here a direct plunger action is obtained. The change in grasp as the plunger moves, however, vitiates this instrument. To overcome these chief difficulties Weiler of Munich has constructed an ingenious dynamometer (Figs. 1791 and 1792) whereby one cannot only obtain the reading but also make a record of it automatically upon a paper ring. With this instrument one grasps a metal cylinder, which suffers almost no alteration in shape or size, permits a firm,

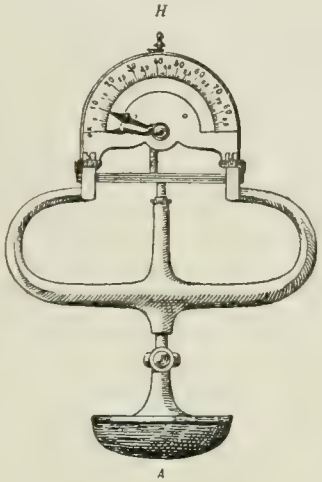


Fig. 1790.—Dynamometer of Chérin and Verdin.

even grasp, causes no pain and makes a record at the same time automatically. Weiler's earlier instrument was too stiff, and a trifle too large, having been constructed to fit the idea of a muscular giant, but later modifications are more available.

The most evident clinical value for the use of the dynamometer is in recording muscular strength variables. Normal individuals show marked variability and also differences in the two hands. Marked reductions in capacity are present in neuritis, in hemiplegia, in various paralyses or pareses, some of which may be of such a mild grade as to escape ordinary observation.

Fig. 1791.—Weiler's Dynamometer.

Roughly used also the ordinary hand dynamometer is of value in bringing out the myasthenic reaction. It also demonstrates very readily the differences between a psychical neurasthenic weakness, an organic weakness, and an hysterical weakness. The curves are characteristic. The so-called normal curve is discussed in the chapter on fatigue. Malingering may also be detected by the use of the dynamometer.

The great advantage of the Weiler dynamometer over all others is in its automatic record. The usual instrument possesses so many errors as to vitiate its accuracy, permits rest from fatigue, calls attention to the operation being performed with every reading, and taken all in all is so crude as to be of value solely in

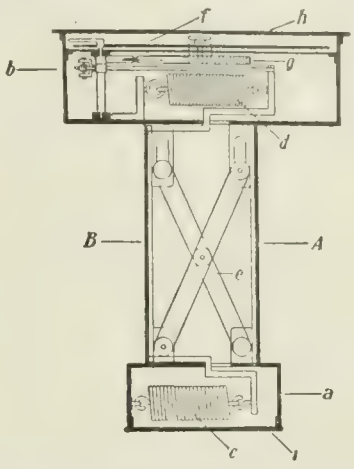


Fig. 1792.—Weiler's Recording Dynamometer; Internal Mechanism.

making crude tests of strength or weakness. The Weiler instrument avoids all of these and is an excellent one for laboratory research as well as of clinical value.

Smith Ely Jelliffe

**Dyscrasia.**—This term (Greek, δυσκρασία, from δυσ-, bad, and κράσις, temperament) denotes a morbid general state resulting from the presence of toxic matters in the body.

The more common varieties are:

Dyscrasia potatorum, dyscrasia of drinking, the aggregate of cachectic phenomena exhibited by those who indulge in alcoholic liquors.

Dyscrasia saturnina, saturnism.

Dyscrasia scrofulosa, scrofula.

Dyscrasia tuberculosa, tuberculosis.

Good discussed dyscrasiæ under *Dysthetica*, in his fourth order, in the Class *Hæmatica*, as a morbid condition of the system of nutrition connected with a faulty state of the blood producing a diseased habit. Good used this term to indicate an ill-conditioned habit of the body originating in or dependent upon the organized parts or fluids of the sanguineous function. Under it he placed the following genera:

(1) Plethora; (2) Hæmorrhagia; (3) Marasmus, emaciation; (4) Melanosis; (5) Struma, scrofula, king's evil; (6) Carcinus, cancer; (7) Lues, venereal disease; (8) Elephantiasis; (9) Catacausis, spontaneous combustion; (10) Porphyra, scurvy; (11) Exangia, vascular divarication; (12) Gangræna; (13) Ulcus, ulcers.

George E. Malsbary.

**Dysentery.**—*Synonyms:* Colitis, Bloody flux; *Gr.* and *Lat.* Dysenteria; *Ger.* die Ruhr.

Dysentery is a term applied to any colitis which is characterized by abdominal pain, tenesmus, and frequent small stools containing a glairy, jelly-like mucus with or without blood. The term *dysentery* is applied not to one disease but to a number of diseases caused by a number of different parasitic infections producing very similar symptoms. The term does not, therefore, cover a diagnosis any more than do the terms "cough" and "fever." Knowledge of the causation of the syndrome covered by the term *dysentery* has advanced materially of late years, many of the causative infections have been differentiated and the subject can now be discussed intelligently. The classification of dysenteries according to their causes, as

outlined by Sir Patrick Manson and later amplified by Castellani and Chalmers (Manual of Tropical Medicine, William Wood and Co., New York, 1913) is acceptable in the light of present knowledge and will be followed with little modification in this article. As these authors have well said, "It is not expedient to attempt to classify dysenteries by their clinical symptoms, or by their postmortem appearances, and any rational classification and description. . . . . must be based on the causation." They therefore classify dysenteries and dysenteric diarrheas as follows:

A. Dysenteries caused by animal parasites.
  I. The protozoal dysenteries.
  II. The platyhelminthic dysenteries.
  III. The nemathelminthic dysenteries.
  IV. The arthropodic dysenteries.
B. Dysenteries caused by bacteria.
  I. The Bacillary Dysenteries.

A. I. The Protozoal Dysenteries.—These are: (*a*) Entamebic dysentery, (*b*) Laveranic dysentery, (*c*) Leishmanic dysentery, (*d*) Ciliar dysentery, (*e*) Flagellate dysentery. The most important of these protozoal dysenteries, because the most widely distributed, is:

(*a*) *Entamebic Dysentery* (*Syn.* Entamœbiasis, amœbiasis, amœbic dysentery).—This is the acute or chronic colitis caused by an invasion of *Entamœba histolytica* Schaudinn, 1903.

*Etiology.*—Entamebic dysentery is found throughout both hemispheres, but is commoner in the tropical and subtropical continental regions and in the tropical islands. Of the known and unknown amebic causes the commonest and therefore most important is *Entamœba histolytica.* This pathogenic protozöon differs both morphologically and in its reproductive process from *E. coli* which is a frequent and apparently harmless inhabitant of the intestine of man. The detailed differences will not be considered here, the reader being referred for these to the article on *Protozoa* in this Handbook. But a gross difference of considerable importance to the clinical microscopist must be mentioned; namely, that in the absence of diarrheic symptoms, *E. coli* becomes encysted and immobile, whereas *E. histolytica* very rarely does so. The importance of this difference to the clinician lies in the fact that the entire absence of motile amebas from the stools during a considerable period following treatment of an entamebic dysentery is satisfactory evidence of cure, while the continued presence of motile amebas in the absence of symptoms is evidence that cure has not been affected and that relapses are to be feared.

The spores of *E. histolytica* appear to be ingested mainly in contaminated drinking water. In the tropics the disease is somewhat more prevalent toward the end of the dry and beginning of the wet season, when the chance of drinking polluted water is greatest. It is no doubt conveyed sometimes in contaminated food. The ingested spores pass to the large intestine where they develop the young entamebas. These invade the mucosa, submucosa, and muscularis mucosæ, and penetrate even the arterioles in which they may cause thrombosis, and the radicles of the portal vein by which they are often carried to the liver. They derive their nourishment from the epithelial and other living cells which they attack and destroy. By their toxicity and the irritation of their presence they cause cellular and edematous infiltration, the casting of minute sloughs, and the beginning of the ulcerative process which is characteristic of a well-established dysentery. The ulcers, becoming infected with bacteria, and extending, often attain a large size with undermined edges. They are usually oval with the long axis at right angles to the axis of the bowel. In some cases the ulcers heal, leaving the intestine deformed or obstructed with dark-colored scar-tissue. In other cases the ulcerative process goes on to erosion of blood-vessels, with hemorrhage, or to perforation of the bowel with abscess formation or general peritonitis; or the process may be so virulent as to cause an extended gangrene of the bowel.

Postmortem, rigor mortis begins early and passes off early. The body is emaciated, and on opening the abdomen a peculiar sickly odor is noticed. The mesocolic glands are usually enlarged and inflamed. The small intestine, the omentum, mesentery, and peritoneum generally may show a more or less extensive inflammation according to the severity, extent, and duration of the disease. The colon may be adherent in places and usually shows an intense hyperemia. On opening it the characteristic infiltration and ulceration are seen more or less throughout its extent, though the changes are apt to be more marked in the cecum and at the hepatic and sigmoid flexures. In cases of long duration bands of dark colored scar-tissue are found at the sites of former ulcers. In long-standing cases of chronic dysentery a peculiar condition is occasionally found at autopsy. The interior of the large bowel is covered with large and long polypoid growths, some of them as long and nearly as thick as the little finger, and so numerous as nearly to fill the lumen of the atrophied and contracted gut. Manson mentions one such case, and the writer has seen a similar one. The term *colitis polyposa* has been applied to this condition. It may be encountered in long-continued chronic cases of either entamebic or bacillary dysentery.

The liver may be congested or inflamed or fatty, or the seat of abscess. Abscess of the spleen occurs occasionally. Heart, lungs, and kidneys show no characteristic changes.

*Symptoms.*—In acute dysentery the onset is sudden. There is usually fever, with rapid prostration, abdominal distress, severe tenesmus, moderate or intense thirst. The patient desires to be constantly at stool, each movement of the bowels giving no relief. The motions are scanty, containing little fecal matter and a good deal of glairy, jelly-like, semi-transparent mucus, usually tinged with blood to a pink or a rusty color and having an extremely fetid odor. The daily motions may be thirty or more. When the process of ulceration has set in, pus, sloughing tissue, and occasionally notable amounts of unchanged blood and clots appear. Gastric digestion is impaired, the tongue is coated, there is anorexia, sometimes nausea, seldom vomiting. Emaciation is rapid. The face becomes drawn and pinched, the pulse weaker and more rapid, exhaustion appears and death occurs frequently in uncomplicated cases in a week or ten days from the onset. In cases where death is due to hemorrhage or perforative peritonitis it may occur earlier or later.

When the temperature becomes normal, the tenesmus and pain abate, and the motions become less frequent and contain more fecal matter and less mucus. These signs are favorable for recovery, though they do not exclude the possibility of intestinal gangrene, of liver abscess, or of the continuance of dysentery in a chronic form.

*Chronic dysentery* may ensue upon an acute attack, or it may, and it very often does, begin insidiously. The patient suffers from intermittent attacks of diarrhea, with abdominal tenderness and with moderate pain and tenesmus, the attacks being separated by intervals of constipation and freedom from any marked symptoms. Patients who have had chronic entamebiasis in this way for years, unsuspected, may develop an amebic liver abscess at any time, or they may suffer extensive colic ulceration which is discovered only at autopsy. Entamebic dysentery is not infrequently of a latent type. In the latent or very mild chronic type, the patient very often develops a marked and otherwise unaccountable *neurasthenia.* In all cases of chronic or recurrent diarrhea, more

especially in all those cases in which mucus is present in the stools, the amœbæ should be searched for. They are easily discovered with a one-sixth dry objective as colorless, refractile, actively motile bodies, from 12 or 14$\mu$ to 30$\mu$ in diameter; and on their discovery appropriate treatment should be given at once. In tropical fields stool examination for all forms of animal parasites has been for some years a well-fixed routine clinical practice, just as urine examination is a routine practice in the temperate zone. The customary neglect of routine microscopic stool examination among physicians in the temperate zone, for the discovery of animal parasites of all kinds, is deplorable, and is responsible for much empirical practice with inexcusable failures in diagnosis and treatment.

*Complications.*—The most important complication to be feared is hepatic abscess, which is discussed elsewhere. Hemorrhage and intestinal gangrene have already been mentioned. Fortunately both of these latter complications are rather rare.

*Sequelæ.*—Hepatic abscess is frequently a sequel, clinically, rather than a complication. Stenosis of some portion of the colon, oftenest the sigmoid flexure, may result from cicatrices.

*Diagnosis.*—From the clinical phenomena alone it is not possible to differentiate entamebic dysentery from bacillary and other forms of dysentery. The only certain method of diagnosis is by the discovery of *Entamœba histolytica* in the stools, which must be examined in a fresh state, shortly after they are voided. *E. histolytica* is to be distinguished from the harmless *E. coli* by its larger size, its more distinct ectoplasm, and the fact that it frequently contains blood corpuscles and bacteria. Its nucleus is eccentric, small, indistinct, does not stain deeply and has little chromatin. Most important of all differences, for diagnosis, is its much more active motility, which is not lost in the absence of diarrhea and during an interval of constipation; as is the case with *E. coli.*

*Prognosis.*—This is grave in severe acute cases and in cases complicated with liver abscess or with gangrene. The prognosis is by no means favorable, either, in cases that have merely been treated empirically until the temporary disappearance of symptoms, and without reference to the extermination of the parasite.

*Treatment.*—Throughout the treatment of an acute case all stools should be inspected and reported by a competent nurse, and the attending physician should inspect the stools at least once daily. The indications in the treatment of entamebic dysentery are (1) to relieve pain and tenesmus, (2) to conserve and support the patient's strength, (3) to cleanse the bowel and kill the parasites.

(1) To relieve pain and tenesmus is necessary not merely for the patient's comfort but to conserve his muscular strength and his nervous vitality in a disease which tends to produce a rapid exhaustion frequently fatal. Laudanum by the mouth in doses of from five to thirty minims is usually combined with a preliminary dose of castor oil or with repeated doses of Epsom salts. A formula well adapted to most of the acute cases at the beginning is: Dissolve one ounce of Epsom salts in eight ounces of water, add one fluidram of laudanum, shake before each administration, and give one ounce of the mixture every hour, with the patient fasting. After a few hours of this treatment the tenesmus has usually abated, the blood and slime in the stools are greatly diminished, the evacuations are much less frequent and less offensive and, though watery, contain some normal fecal matter. If moderate doses of laudanum by the mouth, given in this or some other way, are not sufficient to control pain and tenesmus, or if the stomach is not retentive, morphine should be given hypodermically; or laudanum, morphine, or codeine, in mucilage of starch or in suppositories, by rectum. Heat, or turpentine stupes may be applied to the abdomen. Epsom salts in small doses, without the laudanum, will usually be retained by the stomach even when there is some nausea, and its effect in preliminary cleansing of the lower bowel is so valuable that it should be administered if possible.

(2) To conserve and support the patient's strength absolute rest in bed must be enforced from the beginning, with use of bed-pan and urine bottle. Solid food must be withheld and foods selected which will give a maximum of easy digestibility and nutritive value with a minimum of fecal residue. In some cases a pure milk diet is not sufficiently easy of digestion, and resort must be had to such things as chicken soup, egg albumen, wine whey, and barley water. When the tongue is clean and the patient's digestive force is satisfactory, milk, raw or peptonized, is the staple of diet. Food should not be given either too hot or too cold, as either extreme is apt to provoke peristalsis. Alcohol must be used with caution if at all.

(3) To cleanse the bowel and kill the parasites, the preliminary treatment with a saline laxative having been carried out, the local cleansing and disinfection of the colon should be attempted with enemata. For this purpose, beside plain warm water, solutions in endless variety have been used and recommended, such as saline, astringents, antiseptics, irritants, anodynes. Among the best known and most used are solutions of quinine (1–5,000), tannic acid, silver nitrate, acetozone, alphozone, or thymol (1–2,000), protargol (1–500), creosote (1–300), sodium hypochlorite or boric acid (1–100). Some of these solutions are approximately as inert as water. Some, being irritating, increase pain and are not well borne by the patient, and should not be employed in acute cases. For intestinal lavage per rectum in the early stage of entamebic dysentery with acute symptoms, there is one preparation *par excellence*, namely, a one-half per cent. solution of creolin in water as warm as the back of the immersed hand can comfortably bear. This remedy is antiseptic, mildly analgesic, entirely safe. The patient bears it not only with comfort but actually experiences relief from pain during its retention in the bowel. The writer has employed it for years with the happiest results, and believes that if colic lavage is to be employed in either acute or chronic dysentery creolin is the best of all preparations for the purpose. Needless to say, a reliable creolin must be procured and no chances taken with an unknown and probably imperfect preparation. As to the manner of administering lavage—the patient should be supine, with hips elevated and slightly tilted toward the right, knees flexed and held by an assistant, muscles of abdomen and lower extremities relaxed, a bed-pan in place. Four pints of solution should be placed in a fountain syringe or irrigator, suspended with its outlet not more than eighteen inches above the bed. An ordinary anal tip, properly anointed, should be used, a second assistant with two compresses guarding against leakage. The long lavage tube should not be used. It is unnecessary; it is painful; it may do injury to the inflamed wall in the sigmoid flexure; and anywhere that a tortuosity or constriction may exist, freely moving liquid will pass more easily than any tube. If the patient be apprehensive, reassure him. Allow the creolin solution to enter very slowly. If the patient suffer any sudden discomfort from the distention of an intestinal pocket arrest the flow temporarily by pinching the tube. Massage the track of the colon gently, not by stroking but by alternate patting with the hands, and elicit succussion all the way to the cecum. Endeavor to introduce at least three pints if possible, and to have it retained from one to three minutes.

All the treatment as outlined up to this point having been carried out, and the severe symptoms of the early stage having been relieved, within three or four days

following such relief a course of ipecacuanha should be administered. Clinical experience is supported by accumulating laboratory evidence that this drug is a specific in entamebic dysentery. After a thorough course of it, Brem and Zeiler (*Amer. Jour. Med. Sciences*, November, 1910) have shown that the entamœbæ usually remain absent from the stools and relapses do not occur. The ipecac treatment should be carried out as follows: The patient being in bed, and having taken no food of any kind for three hours, and no raw milk or solid food for six hours, is given from sixty to eighty grains of ipecac in the evening. The ipecac should be of assured purity, not deemetinized. It should be in the form of large oval pills of ten grains each, covered with a one-sixteenth inch coat or shell of fused salol to protect it against disintegration in the stomach. If the patient take his time over it, he will easily swallow six or eight of these large oval pills, one at a time, and will retain them. In very few cases will antiemetic measures be required prior to the administration. On each succeeding night he should take five grains less until a dose of ten grains is reached. The stools should be examined for active amebas weekly for one month and monthly for six months. In a majority of cases the amœbæ, both *E. histolytica* and *E. coli*, will have been exterminated. If they reappear the ipecac treatment should be repeated, and small doses of five to ten grains daily should be given over a prolonged period of a month or so following the second major course of ipecac, and two or three weekly lavages with creolin should be given. Several writers have recently reported apparently successful extermination of entamœbæ in acute and chronic cases by the administration of emetine hypodermically instead of ipecac by mouth. Wadhams has reported the extermination of *E. histolytica* in the intestine following the intravenous administration of salvarsan.

A chronic dysentery should be dealt with on the principles outlined for the treatment of acute cases. Appendicostomy may be resorted to, with occasional success, for therapeutic lavage of the colon in severe or critical cases which have become such because of inadequate early treatment or for any other reason. When in the course of routine stool examination patients are found to have latent entamebiasis they should be promptly treated until the parasites have been exterminated. For the diagnosis and treatment of entamebic liver abscess as a complication or sequel of dysentery, the reader is referred to the article on that subject, and to the published work of Cantlie of London and of Herrick and Noland in the Canal Zone.

*Prophylaxis.*—Filtering and chemical treatment of the public water supply does not remove the infectious amœbæ. In the presence of an endemic the drinking water must be boiled, and uncooked garden produce must not be eaten.

We will now refer to the other known protozoal dysenteries, and, though the reference to each must be brief for lack of space, it must be understood and emphasized that the recognition and appropriate treatment of these other protozoal infections of the intestine are of the highest importance. There is no valid excuse for the customary neglect, by the average practitioner, of correct diagnosis of these conditions by microscopic examination. Inappropriate treatment is not only futile but often injurious. Particularly in our large cities, with a cosmopolitan population drawn from every nation and race, the physician should be on his guard lest he overlook the true cause of a dysenteric syndrome merely because he does not see that cause every day or every year.

(*b*) Laveranic Dysentery.—Caused by *Laverania malariæ*, the hemosporidian of subtertian (estivo-autumnal, pernicious) malarial fever. Diagnosis by examination of stained blood. Treatment by quinine, usually by intramuscular injection.

(*c*) Leishmanic Dysentery.—Caused by *Leishmania donovani*, the protozoön of kala-azar (dum-dum fever of India). Diagnosis by smears from liver puncture. Treatment by intramuscular or intravenous injections of atoxyl, or of tartar emetic; or salvarsan may be tried.

(*d*) Ciliar Dysenteries.—Caused most frequently by *Balantidium coli;* sometimes by *B. minutum*, *Colpoda cucullus*, *Nyctotherus faba*, or *N. giganteus*. Diagnosed by examination of strictly fresh stool. Treatment as for entamebic dysentery, omitting ipecac.

(*e*) Flagellate Dysentery.—Caused by *Cercomonas hominis*, *Trichomonas hominis*, or *Lamblia intestinalis*. Diagnosis by examination of strictly fresh stool. Treatment by lavage with methylene blue (1–3,000) twice daily, and pills or cachets of methylene blue, gr. ii. each (Castellani), warning the patient that the urine will be turned blue.

II. The Platyhelminthic Dysenteries.—Caused by *Schistosomum japonicum*, *S. mansoni*, or *Fasciolopsis buski*.

III. The Nemathelminthic Dysenteries.—Caused by *Œsophagostomum brumpti* in West Africa, or by *Œs. stephanostomum var. thomasi* in South America. It should not be forgotten that the presence of the common *Ascaris lambricoides* in considerable numbers frequently causes dysenteric symptoms.

IV. The Arthropodic Dysenteries.—These are decidedly rare, but they exist, and are caused sometimes by the adults of certain flies (*e.g. Apiochæta ferruginea*) and sometimes by the larvæ of others (*e.g.* the rat-tailed larva of *Eristalis*).

B. Dysenteries Caused by Bacteria.—I. The Bacillary Dysenteries.—Ger. Bacillenruhr. Bacterial dysentery is caused by bacilli either of the Shiga-Kruse type, or of the Flexner-Strong-Manila type, or of the paradysenteric group.

The *symptoms* of bacillary dysentery are quite similar to those of entamebic dysentery, though some general differences between the picture of bacillary dysentery and that presented by entamebic may be noted. Bacillary dysentery occurs not only in endemic but frequently in widespread epidemic form. It is seen with frequency in jails, asylums, and camps. Clinically it is more constantly a febrile disease. It is cultivated in local collections of filth and spread by flies and unclean attendants as is the case with typhoid fever.

*Pathology.*—The bacilli taken into the bowel with food and drink multiply in the intestines producing two toxins (Flexner and Sweet) both of which are absorbed into the blood. One acts upon the nervous system, frequently producing a peripheral neuritis. The other, excreted by the large intestine, acts directly upon its walls in the process, causing infiltration, edema, exudation with formation of false membrane, ulceration, abscess in contiguous structures, and frequently gangrene of the bowel. After recovery from the acute phase of the disease, the colon is often extensively scarred and atrophied, and sometimes presents the picture already described as "colitis polyposa." Bacillary dysentery is a dangerous disease with a high mortality.

*Complications and Sequelæ.*—These are many and serious—hemorrhage, gangrene, abscess, stenosis of the sigmoid flexure, "parotid bubo," neuritis, arthritis, coexisting typhoid or other infection.

*Diagnosis.*—Excluding cancer, syphilis, hemorrhoids, intussusception, parametritis, irritating foreign bodies such as fish bones, and corrosive poisoning, and protozoal dysentery of all kinds being negatived by the absence of parasites, the positive diagnosis can be established only by bacteriological examination of the feces. A shred of mucus or pus is smeared

over a plate of MacConkey's bile-salt-lactose neutral red-agar, and the rod or wire, without recharging, is wiped over a second and a third plate of the same material. Any resulting white colonies are further investigated as to their sugar and agglutination reactions.

*Treatment.*—Beside the same general and local treatment (except ipecac) recommended for entamebic dysentery, the bacillary form should be treated with injections of antidysenteric serum if this is obtainable. The effect is usually satisfactory. If the precise strain of infection be not made out, a polyvalent serum such as that of Shiga should be employed. Shiga's rules for its administration are

1. In mild cases inject one dose of 10 c.c.
2. In cases of medium severity inject two doses of 10 c.c. with a six-hour interval.
3. In severe cases inject 10 c.c. twice a day with a six-hour interval, for two or three consecutive days.

J. F. Leys.

**Dysidrosis.**—See *Pompholyx*.

**Dysmenorrhea.**—Painful or difficult menstruation is known generally as *dysmenorrhea*. This term does not include the sense of discomfort or even the slight backache or moderate pain experienced, by a very large number of women, in the pelvic region during the menstrual epoch. Only when the condition becomes aggravated or is excessive in its manifestations does it fall under the pathological heading of abnormally painful menstruation or dysmenorrhea. The term, likewise, is not properly applied to pelvic pain occurring in the intermenstrual periods, but must be limited to painful manifestations that are present during the waxing and waning of the menstrual wave of congestion—therefore, for the period of two weeks, beginning one week before the appearance and ending a few days after the cessation of the menstruation.

Varieties.—In order to discuss scientifically the subject of dysmenorrhea it is customary to subdivide the condition according to the anatomical seat of the pain or the etiological factor in its development. Thus, *ovarian dysmenorrhea* is that due to disease of the ovaries, such as cirrhosis of the organ or undue denseness or tenacity of the ovarian capsule; *tubal dysmenorrhea* is that due to abnormal narrowness of the tubal canal, or to stricture of the duct or spasmodic and irregular contractions of the muscular walls of the tube; *uterine dysmenorrhea* is that due to abnormal conditions in the uterus itself; and *vaginal dysmenorrhea* is that due to pathological conditions of the vagina. From the etiological standpoint, we may encounter a *congestive* or *plethoric dysmenorrhea*, which results from excessive congestion of the pelvis and its organs; *inflammatory dysmenorrhea*, or that arising directly from acute or chronic inflammation of the pelvic structures; *mechanical* or *obstructive dysmenorrhea*, or that due to some mechanical obstruction to or blocking of the menstrual flow, as when clots are formed in the uterine cavity, or there exists an acute flexion at the internal os uteri; *membranous* or *exfoliative dysmenorrhea*, or that due to the development and shedding or exfoliation of a true membranous structure from the uterine wall, which is discharged in fragments or as a cast of the uterine cavity; and *spasmodic dysmenorrhea*, or that due to irregular spasmodic contractions of the musculature of the uterus or tubes.

Etiology.—The actual cause of the pain in a great majority of the cases of dysmenorrhea is a true uterine cramp, or painful uterine contraction, closely simulating a labor pain. This is especially marked in the cases of dysmenorrhea due to, or associated with, acute anteflexion of the uterus with stenosis of the internal os. Not every case of anteflexion with cervical stenosis, however, will show dysmenorrhea, nor will every case of dysmenorrhea show an evident anatomical or pathological lesion. In such cases a neurotic tendency must be suspected. The cases of membranous dysmenorrhea are beyond controversy cases of true uterine contractions or labor pains, intended to accomplish the delivery or expulsion of the shreds of membrane or actual uterine casts. Ovarian dysmenorrhea is evidently due to an abnormal denseness or toughness of the ovarian capsule, either congenital or inflammatory in origin, with a resultant inability on the part of the mature Graafian follicle to rupture. There results, in consequence, an increased intrafollicular tension, and the sensitive ovarian tissue is pressed upon and squeezed by the follicular cyst or hematoma. This process occurring repeatedly results in the so-called cystic degeneration of the ovary which is accompanied by severe pain during each successive menstrual wave. Not only will the patient suffer intense pain or even agony during the actual process of cystic formation, but she will also suffer more or less during the interval after the wave of menstrual congestion has passed away.

Treatment.—Relief from the pain is imperative. It is for this the patients seek advice, and it is evident that the treatment must vary according to the etiology of the condition. Probably those cases due to stenosis of the internal os uteri with acute anteflexion of the corpus respond most readily to treatment, which, in such cases, consists in a rapid progressive dilatation of the cervix with curettement of the uterine cavity. In order to effect a permanent cure this operation may have to be repeated two or even three or more times. Should a gestation follow the first dilatation nature herself will effect a cure of the dysmenorrhea by the great physiological distention of the organ. The *congestive dysmenorrhea* of endometritis with posterior displacement of the uterus, will require a restoration of the uterus to its normal position with retention of the organ in that position either by a pessary or by some operative procedure, preceded by a curettement of the cavity and an application of tincture of iodine, alone or in combination with carbolic acid, to the endometrium. In all these cases it may become necessary to resort to an immediate treatment with aspirin or some other analgesic and sedative internally, or to a hypodermic injection of antipyrin. The use of opiates or cocaine to relieve the pain of dysmenorrhea cannot be too severely condemned. Thousands of opium habitués have been produced by thoughtless or irresponsible physicians by this pernicious method of treatment. In milder cases, sodium bromide, laxative or purgative remedies, and rest in bed will be sufficient until the flow is established. Hot sitz baths may prove very efficacious in certain cases. The fluid extract of viburnum prunifolium or of hydrastis canadensis, and the tincture of gelsemium have won some repute in these cases of congestive dysmenorrhea. *Membranous* or *exfoliative dysmenorrhea* requires repeated thorough curettements of the uterine cavity followed by cauterization of the walls to prevent a reformation of the membrane. Some of these curious cases will not be relieved until a hysterectomy has been performed. *Ovarian dysmenorrhea*, whether resulting from hematomata and cystic degeneration of the ovarian stroma or from a slowly progressive cirrhosis of the ovary, cannot be cured by any procedure less than the performance of an ovariectomy. Excision of the Fallopian tube likewise will be required when the trouble is located in the tubal mucosa.

W. A. Newman Dorland.

**Dyspareunia.**—This term signifies simply pain or discomfort accompanying the act of sexual intercourse, without distinction as to its causes which are

numerous. It is often confused with vaginismus which was described by Marion Sims and at an earlier period by Huguier, but with which it is not synonymous nor identical, vaginismus being a distinct anatomical condition. Usage has limited the term to women but there is no etymological reason why it should not apply equally as well to men. In the majority of cases it depends upon an hyperesthetic condition of the tissues at the entrance of the vagina, but the cause may be entirely mental. Thus in a woman of neurotic or hysterical temperament the initial coitus may be attended with such physical difficulty or such violence that a profound mental impression is produced which will cause an attempted repetition to be accompanied with great apprehension of pain irrespective of the effect of the act upon the tissues.

The hymen in the virgin is the cutaneous structure which more or less completely closes the entrance to the vagina. It varies greatly in its structural development in different individuals, and is frequently so firm and tough that its rupture requires considerable force. It is not strange therefore that its rupture should be painful, especially as it is located in one of the most exquisitely sensitive portions of the body.

In hundreds of cases the persons concerned, just entering the state of matrimony, are quite ignorant of the physical difficulties which are to be overcome and of the best way to overcome them. Dyspareunia occurs in this class of cases more frequently than in all others combined, and the hemorrhage, which is often associated with the pain, may require the help of a physician for its arrest. The tenderness and inflammation following the initial coitus are sometimes so great that its repetition may be impracticable for a long time.

The hymen may not be the sole cause of the dyspareunia for the muscles of the vagina may be so rigid or subject to such spasmodic contractions that coitus will ever be painful and the pain may appear to be diffused throughout the entire pelvis. But dyspareunia may occur at any period of life, apart from the beginning of matrimony, for almost any form of pelvic disease renders coitus painful.

Displacements of the uterus, especially retroversions and retroflexions, almost invariably condition dyspareunia especially in their early history before the tissues and organs have become adjusted to their unusual relations. Some of the other causes which may be mentioned are prolapse and enlargement of one or both ovaries, polypi, fissures, and caruncles of the urethra, tumors encroaching upon any portion of the vaginal canal, scar tissue resulting from parturition or surgical operation upon the vagina or perineum, fissures or fistulæ of the vagina or rectum, hemorrhoids, etc.

Coitus during pregnancy is often painful and may result in abortion; it is strange that the accident does not occur more frequently from this cause. Abnormalities of structure of the vagina and vulva are causative influences though they are relatively of rare occurrence. Among such abnormalities are septa of the vagina and vulva, bifid vagina, and undeveloped, rudimentary, or rigid vagina and vulva. Attempted coitus through the urethra has frequently been reported where the vagina is absent or rudimentary, and this must be an exceedingly painful procedure.

Injuries to the cervix uteri from parturition are of the greatest frequency and extent and are often associated with more or less serious inflammatory conditions of other portions of the uterus and adnexa. Coitus in such cases usually results in great increase in the secretions of the tissues, but rarely causes pain, such is the insensitiveness of the cervix, when the cervix alone is the seat of disease. Even cancer of the uterus, terrible as are its ravages upon the tissues, is seldom associated with dyspareunia. Hemorrhage in such cases is common enough when coitus is performed, but in the course of a large experience during many years the writer's attention has rarely been called to pain as a disturbing element. It were well if it were a more frequent accompaniment for then an early diagnosis of the disease would more frequently be made and an opportunity afforded for radical operation.

Dyspareunia is only a symptom, but it is present in the large majority of cases of pelvic disease in women, especially in those for which relief is so often sought at our clinics and hospitals and it is therefore a most useful sign in the investigation of such diseases. If sexual intercourse were discontinued and a competent gynecologist consulted when it first became a painful procedure many of the severe diseases from which women suffer could be arrested or could be treated surgically with greater success than may be possible when the disease is firmly established.

Treatment.—In the treatment of dyspareunia it is always more rational to inspect the genital organs before deciding upon a plan of treatment, and if the patient shrinks from such an ordeal, as young married women are apt to do, the examination should be made under anesthesia. This is particularly essential if a digital examination will be required. Frequently nothing will be found which is anatomically wrong and the reassuring words of the physician will allay the apprehensions of the patient.

If the tissues are found swollen and inflamed rest and the application of soothing antiseptic lotions for a few days will be indicated. If thick lumps or masses of residual hymen are found obstructing the vaginal entrance they will be a source of further trouble and ought to be removed. In removing them the vaginal entrance should first be well dilated with the fingers, the redundant tissues excised, and the wounds closed with interrupted sutures of chromic catgut. After the wounds have healed and before coitus is resumed a vaginal speculum should be passed on several successive days. For this purpose a bivalve speculum may be used, but the Ferguson glass speculum is a far more suitable instrument for it not only dilates the vagina more efficiently and with less pain than the bivalve, but it illuminates the entire interior of the vagina and permits one to determine whether all causes of difficulty have been removed.

If the remnants of the hymen consist merely of small tags of tissue they need not be excised but the speculum should be passed several times and the patient directed to take vaginal douches of hot saline solution for several days before attempting coitus again. By this means the vagina will, in most cases, have become sufficiently insensitive to warrant a renewal of the sexual act.

Dilatation of the introitus with the fingers, under ether anesthesia, is proper and is indicated in almost any case in which coitus is painful. In certain cases the entire group of vaginal muscles are rigid and unyielding, and in some of them there are painful contractions whenever coitus is attempted. Such dilatation as has been described may not suffice to overcome this painful spasm in which case a cotton-wool tampon moistened with any approved local anesthetic and smeared with cosmoline may be carefully introduced into the vagina daily for a sufficient length of time. If this fails, and as a last resort several parallel incisions may be made along the posterior vaginal wall and deeply enough to divide the superficial muscular fibers, the vagina being then packed with a strip of antiseptic gauze. A portion of this gauze should be removed daily the four or five succeeding days. It need hardly be added that when inflammatory disease is present, prudence and common sense alike dictate absolute abstinence from coitus and that when tumors or membranes or other physical obstructions cause pain in coitus they should be removed.

When dyspareunia is due to rudimentary or undeveloped vagina and vulva a prolonged course of dila-

tation with proper bougies, worn continuously, will be essential, and this is the more important in view of the mechanical difficulties which would arise should pregnancy supervene.

ANDREW F. CURRIER.

**Dyspepsia.**—This term is loosely defined as difficulty of digestion. It has been divided into different classes, as acid dyspepsia, atonic dyspepsia, catarrhal dyspepsia, and nervous dyspepsia.

The term itself is at present somewhat in disrepute, as may be shown by the fact that, while in 1910 there was published in this country a five-hundred page book with this word as its principal title, in 1913 there has been published another book on diseases of the stomach by a well-known American authority, in which the term dyspepsia does not appear in the index.

Dyspepsia, used alone, means but little, being merely the manifestation of some delinquency in the digestive machinery. The qualified term "*nervous dyspepsia*," however, deserves notice, for under its shibboleth there have been perpetrated many diagnostic errors, and, like the mantle of charity, it has afforded a cover for many therapeutic sins. Such a condition has caused the pendulum to swing rather far in the opposite direction, and, lest the term itself be relegated to the limbo of archaism, it merits a brief consideration.

The frequency of indigestion in its nervous form is hard to determine with any accuracy, owing to the great difficulty of excluding organic affections. This is rendered more difficult by the presence of nervous symptoms in those who also are affected by organic disease. Again, in the hurry and rush of our present-day civilization, it is not easy to get in close touch with the temperamental infirmities and possible mental obliquities of these complaining invalids, so as intelligently to separate manifestations or organic lesions from neuroses. Especially is this true in the larger cities, where a heterogeneous population is engaged in a struggle for existence, and where, unfortunately, in number the unfit predominate.

Another class of patients suffering from so-called nervous indigestion or dyspepsia, possess also visceral ptoses; and, while their neurasthenic symptoms should be taken into account, the ptoses should not be neglected.

The class in whom is found the largest number of real nervous dyspeptics comprises those individuals with fairly good physique, but who have either inherited or acquired an instability of the digestive system, especially in its nerve supply, and whose digestive distress is a true neurosis.

These patients complain of no indigestion when all is well with them, but when beset by worries, financial, domestic, or political, the orderly workings of the digestive tract become awry, and gastric or intestinal discomfort ensues.

Another important class includes men and women of intelligence, who, up to middle age or a little later, lead strenuous lives, hardly heeding the fact that they possess digestive organs, and eating what they desire with impunity. These men and women having attained in a measure the goal of their ambition, attempt to retire from active participation in their former activities, but their busy mentalities, denied regular exercise, train themselves inward, the digestion generally being the first object of analysis. These patients frequently have hardened arteries and impaired kidneys, perhaps pathological changes in other organs too, but this does not nullify the nervous picture.

Let me briefly mention a few instances of nervous dyspepsia, such being familiar to most physicians.

Several years ago I was consulted by ten medical students, juniors and sophomores, who complained of distressing heartburn and flatulence after each meal. This had come on recently, in fact since they had begun "cramming" for the midterm examination, the outcome of which was in grave doubt. Test-meals disclosed hyperacidity in nine out of the ten, but no organic trouble was discoverable in any one of them. Two weeks later, after every one had passed the trying ordeal safely, a second test-meal showed hyperacidity in only one, and none was suffering from any digestive qualms.

A middle-aged widow lady, who was in quite meager circumstances, with the welfare of three children depending on her efforts, found that each month, as the "rent day" approached, she was afflicted with flatulence and pyrosis, which promptly subsided after the rent or other pressing obligations were met.

A successful man of affairs, who had never in his life experienced any trouble in digesting his food, disposed of his extensive interests, retiring absolutely from business. Having nothing else to do, he began to read various "health articles" in the popular magazines, became an earnest advocate of "Fletcherism," devoting his whole time and care to masticating his food and safe-guarding his health. In three months time this formerly cheerful and robust man was transformed into a puny, whining invalid, with every waking thought "short-circuited" on his stomach. Fortunately for him, there came a reverse in his affairs, which forced him to enter again into active business, and, to his gratification, his digestion was soon restored to its former normal state.

A diagnosis of nervous dyspepsia should never be made until a thorough and exhaustive examination has failed to disclose any tangible or organic reason for the symptoms; added to this should be a well-considered anamnesis in the nature of a cross-examination, which, apart from preconceived ideas of the patient, will bring out the real facts in the case. In addition to a careful physical examination of the abdomen, it is essential and almost equally important to investigate the condition of the heart, lungs, and arteries, to examine the blood pressure, the urine, and the reflexes.

In many instances a diagnosis of nervous dyspepsia is made without an analysis of a gastric test-meal. There seems to be a reluctance on the part of some physicians to force upon the patient this examination, but it has been my experience that, if the reason for such an examination is given, practically every one will cheerfully consent.

Certain conditions, being present, as a general rule point to an organic lesion, and exclude the diagnosis of nervous dyspepsia. Most of these conditions may be summarized as follows: Presence in the fasting stomach of more than 30 c.c. of fluid with a strong reaction of hydrochloric acid; persistent hyperacidity accompanied by epigastric pain; achylia with food stagnation, or achylia accompanied by pain or vomiting; the presence of gross and easily recognized food remains repeatedly found in the fasting stomach; epigastric pain recurring at a definite time after eating; chronic drug habituation; and individuals past middle age who have rather suddenly developed digestive disorders, after a previous life of comparative digestive health. It must not be forgotten also, that nervous people may develop organic disease, and that organic infirmities may render previously well-poised persons unstable and nervous.

In nervous dyspepsia the symptoms are shifting and changeable, while gastric or abdominal distress will bear but little systematic relation to the quantity or character of food ingested. Another strong point in the diagnosis of this condition is the ease with which food is digested during periods of rest and recreation, or when the mind is pleasantly diverted and occupied. A dyspepsia that temporarily disappears during a vacation, but promptly returns when the cares of everyday work have been again taken up, may be regarded with suspicion. Another very suggestive

feature in making up the diagnosis is to observe if the symptoms easily yield to nerve sedatives, combined with psychotherapy. Many of these patients, from previous dieting have developed a sitophobia, or fear of food, and in their zealous dietetic efforts have undergone slow starvation, reducing themselves, thereby, to such impoverished bodily state that their nerves are necessarily shaken from center to circumference. Many of these sufferers, too, have labored under the delusion that water or other fluids must not be drunk with meals, and, having but little thirst between, have not ingested enough liquid to enable their bodies to perform the proper "sanitary housekeeping." Such people are sure to be nervous, and if in connection we search for the various psychoneuroses so prevalent under such conditions, a fairly accurate diagnosis may be made.

Treatment.—As to the treatment of these gastrointestinal neuroses and psychoses, I can say that it must embrace more hygiene than dietetics, more suggestion than drugs. It is among these patients that the personal equation of the medical attendant counts for much; for the cheery optimist who can instil hope into doubting and fearing and despondent hearts is the one who gets the best results.

Therapeutic cognizance must be taken of tangible bodily ailments, and appropriate medication has its important place here, as in more material troubles. He, however, who attempts to reach these shifting and evanescent neuroses by a hard-and-fast system of dietetics, stomachics, digestants, tonics, or any other adventitious aids to digestion will be foredoomed to failure. Along the line of uplifting suggestion the isms and cults have won some of their spectacular victories, and the medical profession has been far too slow to gather from these erratic creeds the few real jewels contained therein.

Another therapeutic measure which often proves of benefit is a radical change of occupation or environment. To send the tired city dweller out among the green trees and meadows of the country; to transport the lonely and morbid dyspeptic from the farm to the busy turmoil of the city; to take the "indoor man" from his books or counter, and give him something to do that keeps him out in the open, or to give the wayworn traveler a quiet, perhaps sedentary, occupation—all these in their different aspects will tend to change and divert the diseased current of digestive thought, banishing the subjective symptoms, the introspection, the self-pity.

When the mental artillery of these sorrowful invalids is trained outward instead of inward; when their daily thoughts are lifted out from introspective grooves; when their ill-nourished bodies are furnished sufficient food, and their desiccated tissues are laved with an abundance of water—then can the vicious circle be broken, the nervous dyspepsia conquered, and the psychic aids to digestion resume their normal place in the bodily economy. George M. Niles.

**Dysphagia.**—The term dysphagia (from δυς-, difficult, and φάγω, I eat) means simply difficulty in swallowing, or in deglutition.

Any impairment of the normal process of deglutition may give rise to dysphagia. Such impairment may be organic, and due either to structural lesion or to surgical derangement, or it may be functional, from direct or reflex neurosis. The organic derangements which most frequently cause dysphagia are: acute inflammatory, tuberculous, cancerous, syphilitic, and diphtheritic affections of the mouth, pharynx, tonsils, larynx, and esophagus; affections of the salivary glands, and retropharyngeal abscess. In diseases of the spleen, dysphagia may arise from secondary lymphatic hyperplasia of the tonsils and the follicles of the pharyngeal mucous membrane.

In pressure diverticula or sacciform dilatations of the esophagus, also, this symptom is present. Again, it may be caused by direct pressure of a thoracic aneurysm upon the esophagus, or by that of a malignant new growth located in the pleura or in the posterior mediastinum.

The surgical causative conditions are operations upon, and injuries of, the mouth, tongue, superior and inferior maxillary bones, soft and hard palate and uvula, tonsils, pharynx, larynx, and esophagus. The neurotic conditions most commonly met with are: spasm of the pharyngeal constrictors, paralysis of the velum palati or of the pharynx from some cerebral lesion or as a sequel of diphtheria, general paralysis of the insane, progressive muscular atrophy, glossolaryngeal paralysis, hysterical affections, and, finally, in rare cases, a pharyngeal neurosis of apparently reflex origin. As instances of the latter character may be mentioned those cases in which the spasm occurs in angina pectoris (due probably to the numerous connections between the sympathetic and the vagus), or in pericarditis, not only when the exudation is large enough to cause direct pressure upon the esophagus, but also when there is only a small amount of exudation present.

The disastrous effects of dysphagia will be proportionate to the severity and duration of the cause. While the latter must, of course, largely determine the plan of treatment to be adopted in a given case, there are, nevertheless, certain facts which must be borne in mind when an attempt is made to formulate the measures that should be adopted. Thus for example, it must be remembered that in conditions which are attended with dysphagia, the act of deglutition will produce pain, either local or reflex, or mechanical or chemical injury to parts already inflamed or ulcerated, or both. These, and especially the first, not only by interfering with the ingestion of food, but also by the depressing effect upon the nervous system of frequently recurring pain, may result in impairment of nutrition. The general indications to be met would be, therefore, the securing of rest to the parts, and the avoidance of causes which excite pain; protection of the parts from mechanical or chemical injury; and the maintenance of nutrition.

It is obvious that the above ends must be met by the administration of highly nutritious food, reduced to so small a compass and rendered so unirritating that it can be ingested with the least discomfort and with the fewest acts of deglutition. Thus, in tuberculous or cancerous affections the patient, unable to manage either solids or liquids, will often swallow with success an unbeaten raw egg, a small unseasoned raw oyster, lumps of rennet custard, or some such semifluid and yet coherent bolus. The local pain may be temporarily relieved in many instances by the application of morphine, adrenalin, cocaine, eucaine, orthoform or, in some cases, of menthol.

These means are, however, in a large majority of instances inadequate to fulfil the necessary conditions of rest, avoidance of pain and of injury to the parts, and are, moreover, totally insufficient for the proper nutrition of the patient. In many chronic cases pain and local irritation undergo a steady augmentation, and, in the unequal struggle for life, enough food not being taken at any one time to supply the demands of nature, the patient surely and steadily loses ground. In acute affections of the throat all nourishment will sometimes be declined until the severity of the attack has subsided, thus adding to the enfeeblement caused by the disease itself, and protracting the period of convalescence; while in the surgical conditions above referred to the evils of dysphagia are sufficiently evident.

Since the act of deglutition is the immediate cause of dysphagia, the most rational means for relieving the dysphagia would be, obviously, to remove the causes; in other words, to abolish the act of deglutition. This may be accomplished in the following ways:

1. When there exist both dysphagia and inability on the part of the stomach to retain food, a valuable resource lies in rectal alimentation, the utility of which has been so well established that it is only necessary, in the present connection, to call attention to the importance of its adoption early in the history of the case, and before the strength of the patient has been reduced by want of food.

2. When, on the other hand, the condition of the stomach is good, then, granting the desirability of alimentation by way of the natural passages, the indication is clearly to remove the obstacle to deglutition or to avoid it. The former may be impossible. The latter, however, may be accomplished in a large number of cases by the use of an esophageal tube, through which nutritious food, in liquid form, may be injected into the stomach. The best means for accomplishing this purpose are: (1) the employment of a tube of the smallest possible caliber and (2) the introduction of this tube, not necessarily into the stomach, but merely into the esophagus and past the point of obstruction, or else past the pharyngeal constrictors. Through the tube the stomach may be made to receive food in unlimited amount and variety, without any attempt at deglutition, and with perfect protection to the parts. By this device all of the indications mentioned may be met. The apparatus needed is simple, the essential part of it being an English flexible woven catheter, an open-ended soft-rubber catheter, or a small esophageal tube, attached by means of a piece of rubber tubing to a receptacle for the food. For the latter a glass funnel will be found convenient.

To the great advantage of the catheter over the large and clumsy stomach tube it is hardly necessary to refer. Its introduction is much less startling and uncomfortable to the patient, and, if the food be properly prepared, highly concentrated preparations being employed, after the manner of Debove, the large tube will be unnecessary. As a general rule, the irritation caused by the passage of the tube increases with its size. The tube should be introduced in the usual manner; that is, the patient's mouth being opened and his tongue protruded, the catheter should be carried to the base of the tongue, then the patient should be told to swallow, and, as he does so, the catheter should be pushed into the esophagus, and thence downward as far as may be deemed necessary. The larynx may be avoided with certainty by using the finger as a guide. Before its introduction the tube should be carefully lubricated, for which purpose white of egg, mucilage, and even milk, are useful. An excellent plan is to allow the patient to swallow slowly, just before the introduction of the catheter, a dram or two of pretty thick mucilage. Vaseline, glycerin, and oil are unpleasant to the patient and should on no account be used. In passing the catheter gentleness should be observed, and great care taken to avoid, as far as possible, all points of special tenderness. In many cases the patient himself may be taught to pass the tube much more successfully and comfortably than it can be done for him, since the maneuver is not difficult, and no one knows so well as the patient the exact situation of the painful spots. Sometimes, especially with children, the point of greatest irritability is in the palatine arches, and any attempt at passing a tube across them will be followed by violent gagging. In such cases a soft-rubber tube may be passed through the nostril and pharynx, and thence into the esophagus, and thus contact with the fauces be wholly avoided. Should the introduction of the tube cause dyspnea, direct the patient to take full breaths. The instrument may also cause nausea when it passes the pharynx, and for the relief of this Dujardin-Beaumetz advises the administration of bromide of potassium; and then again it may cause nausea when it reaches the stomach, in case it be inserted so far. In the latter case, however, the introduction of food will quickly bring relief.

The passage of the tube will not always prove an easy or a painless operation. A little practice, however, will generally render its use possible. In cases where the obstruction is impassable the establishment of a gastric fistula may become necessary.

As to the special conditions in which dysphagia will call for relief, the reader is referred to the various articles, in other parts of the Handbook, in which these subjects are discussed. D. Bryson Delavan.

**Dyspnea.**—Dyspnea is a striking symptom of a great variety of diseases, at times very simple of interpretation, at other times requiring a comprehensive knowledge of physical diagnosis, clinical diagnosis, and the symptomatology of disease, in tracing it to its cause. It is a symptom which should stimulate careful effort in differential diagnosis, since it is very seldom that it can be relieved unless its causal disease be correctly diagnosed and treated, and in almost all instances the appearance of dyspnea denotes the existence of some real condition as its cause. Pain, on the other hand, is a common symptom which can usually be relieved without a diagnosis of the causal disease. A correct diagnosis of a disease existing in a patient suffering with dyspnea can frequently be made only after careful and exhaustive examination. The obvious condition is often not the real cause of the dyspnea and it is not unusual to see patients suffering with extreme difficulty in breathing, whose cases have been diagnosed as renal asthma because of the presence of albuminuria, or cardiac asthma because of irregular pulse and cardiac murmurs, but who were greatly relieved by the removal of a large quantity of fluid from the chest. In adult life diseases of the lungs and pleuræ, heart and kidneys, are the most common causes of dyspnea, while in childhood diseases of the larynx, trachea, bronchi, and meninges play this rôle.

While probably every physician knows what dyspnea is and can recognize its presence, yet the term has been used so loosely that its exact definition is difficult. The etymological meaning of difficult breathing is insufficient since it does not include many forms of respiration usually classed under this head. Krehl would go so far as to limit the use of the word to the subjective type of dyspnea. Perhaps the best way is to divide all dyspnea into two forms, the subjective and the objective, remembering that both types are frequently seen in the same patient. Subjective dyspnea may be defined as that condition in which the patient is conscious of a feeling of difficulty in getting his breath, "air-hunger" it is sometimes called. Objectively, the character of the respiration may or may not be altered. Objective dyspnea consists in marked deviation of the respiratory movements from the normal in rhythm or amplitude or both these characteristics. Rapid breathing which is present in many conditions, such as hysteria, fever, etc., is usually not considered dyspnea unless accompanied by distress. Objective dyspnea is frequently accompanied by subjective distress but not invariably so, for one may see a patient with pronounced Cheyne-Stokes breathing, who is wholly unconscious of any alteration in his respiratory movements. If the dyspnea is severe, one or more of the accessory muscles of respiration may be brought into play.

Dyspnea may be continuous or paroxysmal. It may be present only on exertion or it may be so severe as to compel the patient to remain in the upright position so as to favor the auxiliary respiratory muscles, a condition known as orthopnea. The type of breathing may be inspiratory, expiratory, or mixed or there may present peculiar alterations of rhythm or amplitude or both as in Cheyne-Stokes, Biot's, or Kussmaul's breathing. Dyspnea may or may not be associated with cyanosis depending upon whether the altered respiration is able to satisfy the oxygen

demands of the body. The character of the dyspnea is in some instances indicative of the location or nature of the disease causing the trouble. Stenosis of the upper air passages usually results in inspiratory dyspnea. A tumor of the larynx so formed as to act like a valve will cause inspiratory or expiratory dyspnea depending upon its exact location. Biot's breathing has so far been observed only in interference with the nervous mechanism of respiration.

Causes.—The essential cause of dyspnea is a limitation in the interchange of gases between the blood and the atmospheric air. Conditions which bring about such a limitation may be classed as follows: (1) Disorders of the respiratory organs. (2) Disorders of the circulation. (3) Interference with the nervous mechanism of respiration. (4) Changes in the composition of the blood.

1. Many of the common causes of dyspnea in children are found in partial or complete occlusion of the nose or pharynx. Syphilitic coryza, diphtheria, polypi, adenoids, and foreign bodies are the most frequent conditions. In adults an acute inflammation of the mucous membranes or an edematous swelling may cause an obstruction to the respiration. Diphtheria, enlarged tonsils, or a deflected nasal septum may at times be associated with dyspnea in adult life.

Dyspnea is one of the most common symptoms of affections of the larynx, in which case it may or may not be accompanied by aphonia. One of the elements in the cause of any obstruction in the larynx is the muscular spasm which occurs on irritation of the mucous membrane. The presence of foreign bodies, inhalation of irritating vapors, inflammations of the larynx, tetany, eclampsia, epilepsy, chorea, hydrophobia, and tabes, in all these conditions spasmodic closure of the glottis may occur. In children it is frequently sufficient to produce suffocation and cyanosis, while in adults the manifestations are not so marked. In these cases both voice and respiration may be perfectly normal in the aspastic intervals. Edema of the larynx may develop suddenly in a number of conditions. Inflammation of the structures in the neighborhood may be associated with laryngeal dyspnea and this is very apt to be present in the case of tumors or abscesses of these structures. Diphtheria of course has been a frequent cause in children. Perichondritis is an occasional cause. Ulceration or erosion of the laryngeal mucous membrane or the cicatrization of such ulcers may result in a stenosis sufficient to obstruct the breathing. Polypi may be so situated as to cause a valve-like obstruction, in which case, if the tumor is above the glottis the dyspnea is inspiratory, while if it is located below the glottis, it is expiratory. In stenosis of the larynx the difficulty in breathing occurs especially in inspiration, while expiration, particularly the cough, is suppressed as much as possible. Inspiration is protracted and assisted by the auxiliary muscles of respiration and may be accompanied by a loud stridor. Aphonia and orthopnea may be present. The larynx moves downward and there is diminution or entire absence of the vesicular murmur in the chest. Expiration may also be obstructed.

Goiter, tumors of the thyroid, esophagus, and mediastinum and aneurysm of the aorta may cause constriction of the trachea. The presence of foreign bodies and syphilis are occasional causes. Here the respiratory sounds are characterized by whistling râles which reach their climax during inspiration and the difficulty in breathing is inspiratory. The inspiratory downward movement of the larynx does not occur in tracheal stenosis, the head bends forward rather than backward, and the voice is not affected.

Bronchial stenosis is due most frequently to tumors of the thyroid, esophagus, mediastinum, lymph nodes, or lung, or to cold abscesses or dermoid cysts or to ulcerations, cicatrization, or neoplasm of the bronchus itself or to the presence of a foreign body within it. In bronchitis dyspnea may be due to cardiac failure or to the bronchitis itself. Bronchial asthma involves both neurotic and toxic elements but the immediate cause of the dyspnea is conceded to be the constriction of the bronchioles. Bronchial asthma is often very severe with a sudden onset and rapid exacerbation almost to suffocation. The dyspnea is expiratory in character. In capillary bronchitis the dyspnea is often very extreme. In bronchial stenosis, inspiratory dyspnea occurs only in the section of the thorax affected, hence there may be unilateral retraction of half of the chest with inspiratory retraction of the edges of the lungs.

The respiratory muscles may be interfered with. Paralysis of the phrenic nerve results in a flaccid condition of the diaphragm. The respiration is carried on by the muscles of the chest-wall and the diaphragm moves upward in inspiration and downward in expiration, the opposite of its normal movements. Abdominal effusions or tumors or tympanites may obstruct the free movement of the diaphragm. In poisoning with curare death results from paralysis of the muscles of respiration.

Dyspnea is a characteristic symptom of a number of other affections of the lungs. In pertussis the trouble is probably located in the trachea. In pneumonia and pleural effusions it is fairly constant. In pulmonary tuberculosis it is frequently present. In emphysema, congestion, edema, gangrene, and syphilis it is often seen. Pneumothorax and pyopneumothorax act in a similar way to pleural effusions. Tumors of the lung cause dyspnea only when they reach a sufficient size. The adhesions resulting from pleurisy may restrict the expansion of the lung, while in acute dry pleurisy the dyspnea is due to the pain caused by breathing. Pulmonary thrombosis or embolism is regularly accompanied by a dyspnea which may be very severe. The dyspnea seen in scoliosis is usually due to a secondary involvement of the circulation.

2. In congenital defects of the heart, in acquired valvular lesions, weakness of the heart muscle, or the presence of fluid in the pericardial sac, dyspnea frequently appears with the break in compensation. In acute endocarditis dyspnea is less constant. In all cases of dyspnea due to cardiac failure the secondary effect of the altered blood supply of the respiratory center has its influence. Dyspnea may also be a symptom of cardiac neurosis as in paroxysmal tachycardia. The dyspnea associated with arteriosclerosis is due to the secondary involvement of the heart, kidneys, or brain. Dyspnea is usual in purulent aortitis.

3. Interference with the nervous mechanism of respiration occurs in a very large number of diseases and conditions. In affections of the brain such as meningitis it is often seen. So also in tumors of the brain and in reflex disturbances from gastric, nasal, or hysterical conditions there may be distressing disturbance of the respiration. The respiratory center is subject to the influence of many toxins. The dyspnea seen in infectious diseases is usually toxic as is that which occurs in nephritis, anaphylaxis, uremia, and diabetes. Morphine, chloroform, alcohol, tobacco, belladonna, strychnine, ether, and carbolic acid are the more important poisons which may cause dyspnea by action on the nervous system.

4. In the various anemias, both primary and secondary, when sufficiently severe, dyspnea is a frequent symptom especially on exertion. In some forms of poisoning the ability of the blood to carry oxygen is interfered with and dyspnea may result. The most prominent of these poisons are carbon monoxide, the nitrites, the aniline compounds, prussic acid, and potassium chlorate.

In a general way this classification covers all of the causes of dyspnea. For a detailed consideration of them the reader is referred to "Dyspnea and Cyanosis" by Prof. Edmund von Neusser, translated by Andrew

MacFarlane, New York, 1907, which embodies a very complete discussion of the subject.

The treatment of dyspnea resolves itself into the treatment of the cause.

Cheyne-Stokes Breathing.—This is a form of periodic respiration seen in apoplexy, tumors of the brain, meningitis, uncompensated heart lesions, and various toxic conditions. The patient is usually stuporous or comatose, though occasionally conscious and not aware of his respiratory peculiarity. In this form of breathing there is a cycle consisting of two periods of nearly equal length. The period of apnea, during which there is not the slightest respiratory effort, lasts a variable length of time, from a few seconds to two minutes. This is followed by a period of active respiration which is generally a little longer than the period of apnea. A very faint, scarcely perceptible, sighing respiration first occurs; this is followed by gradually increasing and deepening respirations, till in marked cases abnormally deep and loud respirations, accompanied by snoring or groaning sounds, are taken. The respirations now gradually decrease in strength, running down the scale, till the period of apnea is again reached. This cycle may be repeated for days, weeks, or months. Cheyne-Stokes breathing is a bad prognostic sign, for though the patient may improve and resume normal respiration for a time, he is almost certain to relapse. A form of this breathing is seen in infants with meningitis and is called "infantile Cheyne-Stokes." In this form there occur three or four regular shallow respirations followed by a period of apnea of approximately equal length.

Biot's breathing has been observed only in meningitis. It consists of an absolutely irregular respiration. Long periods of apnea, sometimes lasting thirty or forty seconds, are interspersed with periods of respiration which are marked by deep sighs and variations in the rate and depth of respiration. There is an absolute absence of rhythm.

Kussmaul's breathing is an accelerated, regular, strongly dyspneic, and deep respiration which is said to be characteristic of diabetic coma.

James Rae Arneill.
Revised by Ralph G. Stillman.

**Dystocia.**—Though this term is used by some writers to signify pathological labor in every form, such usage does violence to its etymology which comprehends only labor that is difficult or retarded.

Labor may be difficult in consequence of fault in the fetus, in the passage through which the fetus is projected, or in the force by which it is projected. Further it may be difficult on account of certain influences which sometimes act unfavorably upon the expulsive forces and the fetus, but at other times do not. In other words there are actual and potential influences which are related to dystocia.

Fetal Causes.—Relative to the passage through which it is to be projected, the fetus, particularly the head, may be too large or too small. It is strange but true that a small head frequently results in dystocia, especially when the pelvis is very roomy, for the head may not engage at the brim, the mechanism of labor may be imperfectly carried out, and the presentation will consequently be faulty. The occipitoposterior presentation is frequently brought about in this way.

But mere size or bigness does not necessarily result in dystocia for the fetal tissues may be so soft and compressible that they will slip through a pelvis in a way which would have been declared impossible by all the laws of mechanics. The heads of monstrosities even when huge in size may be so compressible that they can be crushed between the fingers. The moulding of a large head in a pelvis with abnormal dimensions is often so easily accomplished that the labor will have neither difficulty nor peril.

Whatever the size of the fetus, its malposition usually determines dystocia; whether the presentation be occipitoposterior, face, brow, breech, or transverse, all cause delay and often difficulty in the delivery. This does not mean, however, that artificial delivery will be required in every case of dystocia, for artificial delivery and dystocia are by no means synonymous and identical.

A head which is too hard for proper moulding is as likely to produce dystocia, in the form of retarded labor, as one which is too large or too small, and the same result is probable when the body is overdeveloped and the tissues unusually firm, particularly at the shoulders.

Death of the fetus frequently postpones labor, but if the child is normally developed and the parturient canal is normal, it will seldom cause dystocia. The induction of labor will sometimes be required but if the woman's physical condition is good it usually proceeds to a normal termination.

Plural fetuses and monstrosities are often a cause of dystocia, on account of the interlocking of their limbs or bodies, and the length of time which is consumed in the process of their birth. On the other hand twins and triplets are usually smaller individually than the products of single births, and if the parturient canal has been sufficiently dilated to permit the passage of one fetus it will the more readily permit the passage of a second. The birth of monstrosities is often difficult or delayed, though the parturient canal and the expulsive force may be normal, because their excessive or defective development is incompatible with the normal mechanism of labor. A very short or a very long umbilical cord will cause dystocia unless the placenta and membranes become sufficiently detached to progress *pari passu* with the fetus. When the cord is very short it may be broken in the onward progress of the fetus, and when it is very long the coils around the neck or body may be so tightly drawn that the fetal circulation will be cut off, the result being usually fatal to the child in either case.

Dystocia may be due to the toughness and inelasticity of the membranes, their dilatation by the liquor amnii being insufficient, and the dilatation of the cervix and vagina being retarded in consequence. Again the membranes may be so adherent to the uterus by inflammation or other cause, or they may be so irregularly attached, sacculated, or pouched that the third stage of labor will be retarded and may not be terminated until they have been removed by hand.

Maternal Causes.—There are many causes of dystocia in connection with the parturient passage which may involve the hard tissues, the soft tissues, or both. The hard tissues, that is the bones of the pelvis and those which are adjacent to them, are at fault in many cases. In the pelvis which is too large, the justomajor pelvis, the fetal head being of normal or subnormal dimensions, dystocia is frequently associated with the occipitoposterior presentation, and less frequently with that of the face, brow, breech or transverse. In the pelvis which is small, but of good proportions, the justominor pelvis, we often have a retarded labor which may be relieved by the separation of the joints of the pelvis but which may also demand artificial termination. Pelves which are flat, abnormally inclined, distorted by injury or disease, obstructed by tumors or are irregular in any way in their anteroposterior, oblique, or transverse diameters are almost always efficient causes of dystocia, and there is no division of obstetric art and literature which has been more carefully worked out and thought out than this. The danger to both mother and child from dystocia originating in this source is probably greater than from any other, for the bony structure

of the pelvis yields only at the joints and the space thus gained may be insufficient to facilitate the progress of the fetal body.

Dystocia which originates with the soft tissues of the parturient canal is of far greater frequency than with the hard tissues.

Rigidity of the cervix, as a cause of dystocia, is constantly observed. It is extremely common in primiparæ, sometimes being relieved by nature, but often requiring the help of the accoucheur. It may be due to faulty development of the uterus, to atresia, or to cicatrization resulting from previous labors or from surgical operations. Not infrequently the advancing head of the fetus presses the anterior lip of the cervix forward, it becomes edematous and perhaps impacted behind the symphysis pubis, and from this cause labor may be long delayed. Versions and flexions of the uterus prevent its proper dilatation and are also a cause of retarded labor. The same is true of hernia of the uterus through the divided muscles of the abdominal walls and in fact of any misplacement of this organ.

Ventral suspension of the uterus in women who are still of the child-bearing age is a prolific cause of dystocia and hence has been abandoned by prudent surgeons as a proper surgical procedure. In numerous reported cases of this condition delivery has been found impossible until the obstructive band was cut, but even this has at times been found insufficient, cesarean section being necessitated.

Dystocia results when tumors, either solid or cystic, obstruct the parturient canal. Such tumors may be outside the uterus and more or less completely fill the pelvis, pedunculated fibromata of the uterus, dermoids and cysts of the ovary being common examples, or they may be within the uterus itself in the form of submucous fibromata and fibroid polypi. Such a complication of labor is a very bad one and the dystocia may continue until the tumor is pushed out of the pelvis or is removed. If the tumor is within the uterus it may be detached by the uterine contractions and be spontaneously delivered after the delivery of the fetus. Tumors of the vagina resulting in dystocia are rare but possible occurrences; of greater frequency are tumors of the vulva, including cysts, edema, hematomata, and abscesses. Rigidity and stenosis of the vagina and vulva are occasional impediments to labor, particularly in women who are very young or imperfectly developed.

Developmental anomalies should also be mentioned as causes of dystocia, and include bifid uterus and vagina, bicornate uterus, vaginal septa, and thick and tightly closed hymen. Pregnancy in a bicornate uterus, or in one horn of a bifid uterus is not only apt to result in dystocia but endangers the patient's life should the uterine contractions be very strong. Of the dystocia which may result from hernia or ptosis of the intestines or bladder mention must also be made. The former is not infrequent and may be the source of great trouble.

Dynamic Causes.—Dystocia due to the expellent force is most frequently observed in the form of uterine inertia when this force is inefficient or wanting. If it occurs when the contracting force is ample it is usually attributable to one or another of the various causes which have already been cited. It may be irregular in its application and produce twisting of the uterine fibers the so-called "hourglass" contraction, or it may be tetanic and forbid proper dilatation.

When the uterus is misplaced or attached to the abdomen by a suspending band the contracting force is certain to be misdirected and result in dystocia. Among the potential causes of dystocia may be mentioned hemorrhages either of the uterus, vagina, or vulva, convulsions, prolapse of the cord, and rupture of the uterus. Sometimes these conditions, all of which are of grave importance, are not so much the cause as the result of dystocia. To this list may be added inversion of the uterus which, while it may be a sequel of violent and precipitate labor, may also result from a labor which has been long and troublesome.

Andrew F. Currier.

**Dystonia Musculorum Deformans.**—Under this term Oppenheim includes a peculiar syndrome, first called attention to by Ziehen as a tonic torsion neurosis. Flatau and Sterling term it a progressive torsion spasm. It is preeminently a disorder of children, most of the observed patients having been between eight and fourteen years and almost all of the Jewish race. Apparently there are no sex differences. Oppenheim's cases did not lead him to any light on the disorder as hereditary. Three of Ziehen's cases were brothers and sisters. Exciting or other causative factors are not known.

The illness comes on apparently gradually and subtly in one arm or in both arms, occasionally first in the legs or in the spine, but in progression. The patient twists the spine in a very peculiar fashion, tilting the pelvis, and bringing about a marked torsion of the entire vertebral axis, with lordosis, scoliosis, and tilting of the pelvis, the arms and legs moving in a peculiar manner. The mode of progression at times resembles that of an astasia abasia. The whole musculature when in action is extremely stiff and hypertonic. When at rest hypotonia is apparent. In the general attitude of the patient in walking one is inclined to regard the whole matter as one of extreme suggestibility—a psychogenic-hysteriform affair. These cases have been diagnosed as hysteria, and some of the patients shown in the United States as Oppenheim's disease have been hysterical. The case of Belings and possibly a negro in Jelliffe's service at the City Hospital, illustrations of whose progressions are here given, are to be reckoned with the cases of Ziehen-Oppenheim's disease. The movements of the hip are very typical. It is tilted or thrust forward or backward in a very awkward manner. Oppenheim has likened it to a dromedary in some of the positions assumed. Walking seems to fatigue the patients greatly. They perspire, get red, and show signs of fatigue, getting out of breath, and, as in the case of one of my own patients, grunt involuntarily. One of Oppenheim's patients could walk backward better than he could walk forward. On sitting down or lying down the movements cease (Beling's case) or are much reduced in frequency and in clownishness. Ziehen's patients were at times continually in motion and had to be kept in a special bed against which they frequently bruised themselves by their impulsive movements. The peculiar activities come into play as soon as there is an attempt to make any voluntary movement. Writing becomes difficult or impossible. There is no paralysis. Oppenheim speaks of a dystonia, Ziehen of a hypertonia. The movements are not athetoid nor choreic. They are wide, irregular, and yet partake of the nature of both, and at times resemble those of Huntington's chorea.

Tonic and clonic extension of the muscles, particularly of the biceps and rotators of the thigh, were marked in Oppenheim's cases, also in that of the negro here pictured. Thus there is an alternation in tonicity of the muscle.

The knee jerks are apt to be much diminished, coming out in Oppenheim's cases only by Jendrassik aid.

The relationships are difficult to state. Hysteria should be excluded. Double infantile athetosis shows a similar picture, with which the negro mentioned may be nearer allied than with dystonia deformans. These cases have been studied especially by Lewandowsky (*Deutsche Zeitsch. f. Nervenheilk.*, xxxix., 1908). Cecile Vogt and Oppenheim have reported on infantile pseudobulbar palsy, which also is to be considered in this connection (*Journal f. Neurologie*, xviii.,

1911). The negro in question had the pseudobulbar symptoms more marked at certain times than at others. The patients apparently hold their own for some time, and but little is known of the development of the disorder. As yet no pathological reports are available. No known method of treatment seems to be of service. Suggestion is of no value, nor are bromides. The movements cease during sleep. SMITH ELY JELLIFFE.

**Dystrophia Adiposogenitalis.**—See *Hypophysis Cerebri*.

**Ear: Anatomy of the Auditory Canal.**—The external auditory canal, or meatus auditorius externus, extends from the bottom of the concha to the tympanic membrane, and serves to convey sound vibrations to the middle ear.

It develops in the embryo from the persistent portion of the first outer visceral furrow, making its appearance during the fourth week of fetal development.

The center of ossification shows itself during the third month in the lower wall of the membranous canal.

At birth this bone development has assumed the shape of an incomplete ring; *the annulus tympanicus*. This ring presents a slight groove along its concave border for the attachment of the tympanic membrane, the deficiency upward and backward forming the so-called Rivinian fissure or notch.

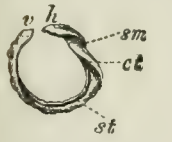


FIG. 1793.—Annulus Tympanicus of the Left Side, as Seen from the Inside of the Tympanum. (After Gruber.) *h*, Anterior, *v*, posterior upper end; *sm*, sulcus malleolaris; *ct*, crista tympanica; *st*, sulcus tympanicus.

At birth the auditory canal is a partially collapsed tube, the roof and floor being in contact throughout a considerable portion of its extent and containing small masses of broken-down epithelial scales and vernix caseosa.

During the first few years of life we find proportionately little difference in the length of the canal when compared with that of the adult, twenty millimeters being about the average length at birth. The caliber of the canal is smaller and more oval in shape. The general direction is straighter, passing inward with a decided downward inclination, so that when examining the membrana tympani in the child the speculum can be used to more advantage if the external ear be pulled downward and outward.

The fully developed adult canal is made up of an inner bony portion and an outer cartilaginous and membranous portion. The bone formation extends from the annulus tympanicus outward in the membranous canal, forming the anterior, inferior, and a portion of the posterior bony wall of the perfected canal. The roof is formed by the horizontal plate of the squama and the root of the zygoma; the posterior wall by the annulus, squama, and mastoid prominence.

The outer portion of the canal is a continuation inward of the cartilage of the auricle, the cartilaginous elements being absent in the upper and posterior portion, this gap being filled in by fibrous membrane. The amount of cartilage making up the canal is found to lessen as it extends inward; at its commencement two-thirds of the circumference is composed of cartilage, at its attachment to the bony canal it represents less than one-third of the lower front wall. The cartilaginous portion is attached to the roughened edge of the tympanic ring—now developed into the bony external auditory canal—by fibrous tissue. The fibrous portions of the upper and back wall become merged into the periosteum of the mastoid and squamous portions of the bony canal.

The length, size, and shape of the canal vary according to age, race, and the form of cranial development. The length of the canal is stated variously by different authors, depending on the points from which the measurements are taken; the average length from the bottom of the concha being about twenty-four millimeters, of which sixteen millimeters are found to be bone and eight millimeters cartilage.

Von Troeltsch has given the most complete measurements of the different walls. Starting from a plane drawn from the posterior wall at right angles to the

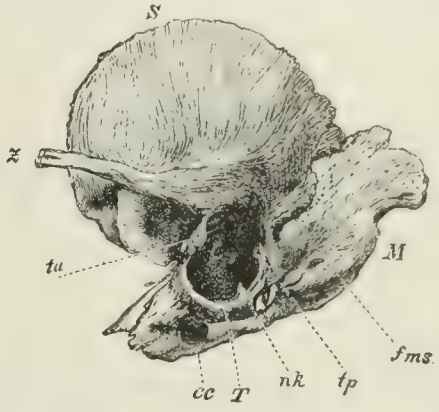


FIG. 1794.—Temporal Bone of New-born Infant. (After Gruber.) *S*, Upper part of squamous portion; *M*, mastoid portion; *Z*, zygomatic process; *T*, tympanic cavity; *fms*, fissura mastoides squamosa; *cc*, foramen caroticum; *ta*, *nk*, *tp*, bony processes representing the beginnings of growth outward on the part of the annulus tympanicus.

axis of the canal, he found the following measurements: Anterior wall, twenty-seven millimeters—nine millimeters cartilage, eighteen millimeters bone; inferior wall, twenty-six millimeters—ten millimeters cartilage and sixteen millimeters bone; posterior wall, twenty-two millimeters—seven millimeters cartilage, fifteen millimeters bone; superior wall, twenty-one millimeters—seven millimeters cartilage, fourteen millimeters bone; the variations in the length of the different walls being due to the oblique position of the tympanic membrane at the inner end of the canal. The shape of the canal at the external orifice is somewhat oval, the long axis inclining slightly backward from the vertical.

Ostman, from a study of 2,302 skulls, found that with the dolichocephalic skull the canal was shorter and more circular, while in the brachycephalic skull the canal was longer and more oval. It is a clinical fact that in the negro race the canal is more circular and straighter, making it often unnecessary to resort to the speculum in order to view the tympanic membrane.

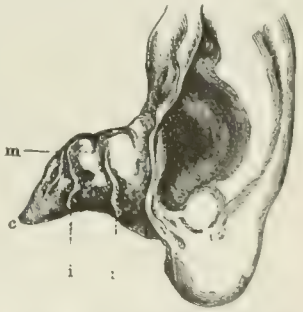


FIG. 1795. —*m*, Cartilaginous meatus; *c*, inner extremity of the cartilaginous meatus; *i*, *i*, fissuræ Santorini.

The smallest diameters of the canal are near the end of the cartilaginous portion, and in the bony canal close to the inner third. The following diagrams show the shape and size of the canal at different parts of its course, as found by Bezold from a study of casts of the cavity.

The direction of the canal is sigmoid. In its outer third it is inclined somewhat forward and ascends very slightly. It then turns sharply backward and is horizontal near the middle third, where it again

changes its course, the inner portion curving forward and decidedly downward.

In the cartilaginous floor of the canal are found one small and two large fissures running in a circular manner, called the fissures of Santorini. These spaces are filled in with fibrous tissue and allow the passage of blood-vessels; at the same time they permit free motion of the canal, thus favoring the straightening of the meatus during examinations with the speculum. These fissures are sometimes the channel

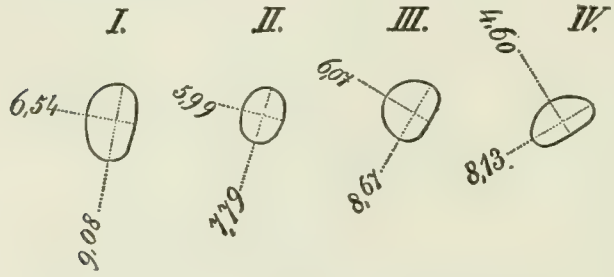


Fig. 1796.—Diagram Showing the Form and Measurements of Sections Across the External Auditory Meatus. (From Schaefer, after Bezold.) *I.*, At commencement of cartilaginous portion; *II.*, near end of cartilaginous portion; *III.*, near beginning of osseous portion; *IV.*, near end of osseous portion. (The measurements are in millimeters.)

through which an abscess in the parotid gland may find its exit.

The canal is lined by a continuation of the cutaneous covering of the auricle. In the cartilaginous portion the skin is one to two millimeters in thickness and loosely attached to the perichondrium. In the bony canal it is thinner and firmly united to the periosteum.

Kaufman describes a number of ridges or vascular papillæ which occupy a circular position in the skin of the osseous portion of the canal, close to the membrana tympani, and which, in inflammatory conditions of the canal, may become quite large. Politzer states

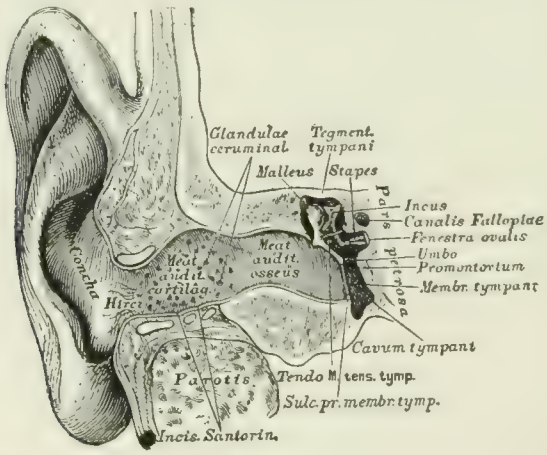


Fig. 1797.—Vertical Section of the External Auditory Canal and Tympanic Cavity. (After Heitzmann.)

that these papillæ are often the starting point for polypi. At the inner end the skin continues over the membrana tympani and forms its outer layer.

Throughout the cartilaginous part, and extending in a triangular manner into the upper and back wall of the osseous canal, are found numerous hairs and sebaceous glands, and in addition, large oval, convoluted tubular glands resembling in form and structure the sweat gland—the *glandulæ ceruminosæ*. These glands secrete the cerumen or ear wax, and are found opening into and around the hair follicles. The hair development is sometimes abundant. The sebaceous glands secrete a small quantity of oily material for lubrication of the skin.

The secretion from the ceruminous glands when first discharged is of a yellowish-brown color and soft in consistency, but in a short time evaporation of the watery elements causes the mass to thicken and it becomes darker. Often it becomes inspissated, and by blocking the canal gives rise to much temporary discomfort. It is of a pungent, bitter taste, and chemically, in addition to oil from the sebaceous glands, is made up of a dry material not soluble in water, alcohol, or ether, and of potash, stearin, a trace of soda and lime, and 0.1 per cent. water, mixed with numbers of broken-down epidermic exfoliations and loose hairs. Röhrer found a number of organisms existing in plugs of ear wax. The function of the cerumen is probably to protect the ear from the entrance of insects and foreign particles that may get into the canal.

Of the very greatest importance to the aural surgeon is the surgical anatomy and relationship of the canal. These differ somewhat in the ear at birth and in the adult. At birth the only portion of the canal found to be bony is the *annulus tympanicus*. This is attached to the squama in front, below and behind to the petromastoid portion. Along the external margin of this ring are seen two small tubercles that are the starting points for the future bone development forming the anterior and lower wall of the canal. They do not immediately unite as one process, often leaving a gap until after the fifth or sixth year.

The roof of the canal is formed from the squama. As development takes place the portion below the temporal line assumes a horizontal position and presents two plates of bone containing between them honeycombed spaces. The superior plate forms a part of the floor of the middle cranial fossa and has resting upon it the dura mater. The lower plate, near its inner extremity, suddenly drops down in the outer wall of the attic of the tympanum, called the scutum, and gives attachment to the upper margin of the drum-head. The cell spaces contained between the plates of the roof of the canal frequently communicate with the antrum and with the pneumatic spaces found as far forward as the root of the zygomatic process. Clinically these spaces are of importance since they may be the seat of suppuration in conjunction with mastoid diseases, and must not be overlooked in operations in which all the cellular spaces are suspected of containing pus.

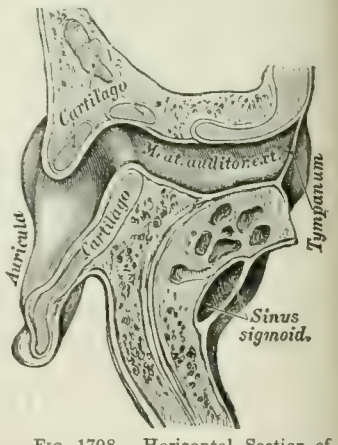


Fig. 1798.—Horizontal Section of the Left External Auditory Canal. (After Heitzmann.)

The anterior bony wall of the meatus is the thinnest of the canal. It is slightly convex on the meatal face. Its front surface assists in the formation of the glenoid cavity in which rest the condyle of the lower jaw and part of the parotid gland. Blows on the lower jaw are therefore likely to fracture the wall of the canal.

The floor is formed by the bony growth of the tympanic ring. It is thick and compact; toward the meatus the surface is convex except close to the membrana tympani, where a small concavity is

found—"the sinus of Meyer"—in which foreign bodies lodge. The position of this concavity is such that it is often difficult to detect the presence of these foreign bodies and to remove them.

The posterior wall of the osseous meatus is of much surgical importance. It is formed by the union of the tympanic ring with the squama, and later with the anterior plate of the developed mastoid, this plate being quite thin and separating the canal from the cell spaces contained in the mastoid. Often the groove for the lateral sinus is in close proximity to this wall.

At the juncture of the upper and the posterior wall the scutum forms a portion of the outer wall of the mastoid antrum. In suppurative diseases of the tympanic cavity carious tracts (fistulæ) are often found in this region; they lead into either the tympanic attic or the antrum of the mastoid, and call for surgical interference. Just external to the upper posterior margin is often found a small bony spine—the suprameatal spine—which is of value as a surgical landmark in the operation for opening the mastoid antrum.

In the fully developed ear the drum is placed in an oblique position, the upper and back part forming an obtuse angle of about 135°, while the lower and anterior portion forms an acute angle of about 40°, with the canal wall.

The arterial supply to the auditory canal is quite abundant. The posterior auricular, a branch of the external carotid, sends a branch called the auricular. It passes in at the junction of the cartilaginous with the bony canal, and supplies the back wall of the canal, anastomosing with the anterior auricular, a branch of the temporal, which enters the anterior wall of the canal behind the condyle of the lower jaw. The tympanic branch of the internal maxillary enters the tympanic cavity through the Glaserian fissure, and sends a branch that supplies the skin of the canal adjacent to the membrana tympani. The veins take an irregular course. They empty their blood either directly (and this is the rule) into the external jugular or indirectly by way of the temporal or the internal maxillary vein.

The nerve supply is, first, from the auriculotemporal branch of the inferior maxillary division of the fifth nerve. Three small branches of this nerve supply the skin on the anterior wall and in the cartilaginous portion. Second, the auricular branch of the pneumogastric—"Arnold's nerve"—enters the back wall of the canal at its junction with the mastoid, and supplies the larger portion of the bony canal and a part of the back wall of the cartilaginous section. Irritation of this nerve by the accumulations of wax, by foreign bodies, or by the speculum when the ear is being examined or cleansed, produces the familiar reflex ear cough.

But little seems to be known regarding the lymphatic vessels contained in the walls of the external canal. Politzer states that they are probably connected with the lymphatic glands overlying the parotid, by way of the fissures of Santorini, since it is a matter of clinical observation that swelling of the lateral cervical glands often occurs in inflammatory conditions affecting the meatus.

The skin lining the auditory canal maintains all the histological characteristics of the skin in other parts of the body, although that part which lines the bony canal becomes very firmly united to the periosteum and altered in color. In its development there is a gradual growth outward of the skin, thus producing a constant tendency for the ear wax to move outward, this being further facilitated by the pressure of the condyle of the jaw, which in mastication constantly pushes the parotid gland against the anterior wall of the canal and somewhat influences its lumen.

The sinuous course of the canal is such that sound waves do not strike the membrana tympani directly, but are reflected from the walls of the canal and are thus modified in their intensity. Politzer states that the two most important points where this reflection takes place are on the back wall of the cartilaginous canal and on the anterior inferior portion of the bony canal.

The size of the canal plays no influence in the acuteness of hearing, although Burnett observes that large straight canals are more likely to be found in those possessing a so-called ear for music.

J. Morrison Ray.

**Ear: Anatomy of the Auditory (Acoustic) Nerve and its End Organs.**—Comparative Anatomy and Physiology.—The functions of audition and equilibration seem to be closely associated throughout the animal kingdom. The so-called auditory organs, or otocysts, of the invertebrates are in the majority of cases concerned largely, if not wholly, with equilibrium, though in some cases (notably among insects) true auditory organs undoubtedly exist. The structure of these organs is usually similar to that of the organs in the labyrinth of vertebrates.

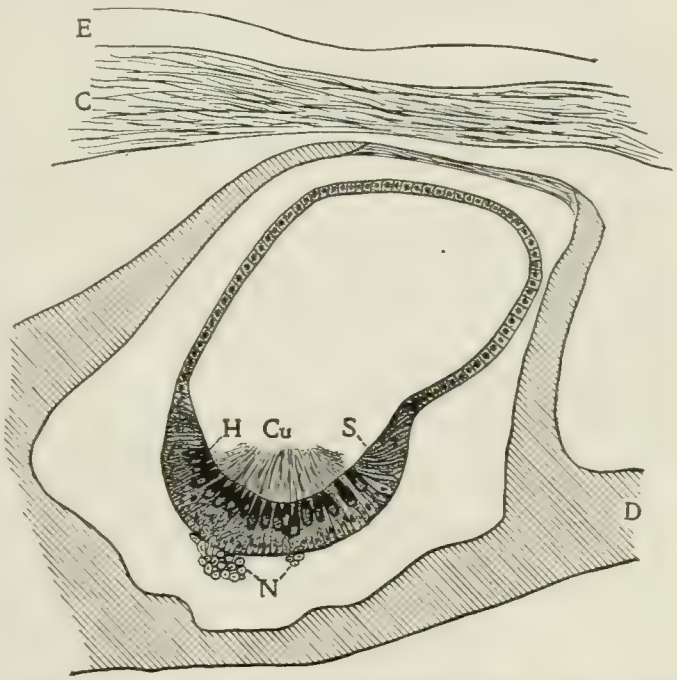


Fig. 1799.—Section through a Typical Lateral-line Organ of *Menidia* (the Fourth Canal Organ of the Mandibular Line of Fig. 1800). *C*, Corium; *Cu*, cupula, composed of hairs from the hair cells matted together and more or less gelatinized; *D*, dentary bone; *E*, epidermis; *H*, hair cells, or specific sensory cells; *N*, nerve fibers supplying the latter; *S*, supporting cells.

For the proper morphological comprehension of the eighth nerve and its terminal organs we must look far back to the early phylogenetic stages of its development in the vertebrates. The fishes possess a system of cutaneous and subcutaneous sense organs, the so-called lateral-line organs (Fig. 1799), widely distributed over the head and trunk. Part of these are in canals (the lateral line or "mucous" canals), and part are variously distributed over the skin, either naked or sunken in separate pits (the pit organs of ganoids and

ampullæ of elasmobranchs); but all closely resemble structurally the maculæ and cristæ of the internal ear, and all are innervated by nerves which effect connections centrally, along with the auditory nerve in the area acustica. These lateral-line nerves go out with the vagus and facial roots and are conventionally associated with these nerves. They have, however, no physiological connection with them, but are more logically associated with the auditory nerve to comprise the "acustico-lateralis" or special somatic sensory system of nerves (*cf. Cranial Nerves*). The peripheral distribution of this component in a typical fish is expressed in the accompanying diagram (Fig. 1800).

The chief function of the lateral-line organs of fishes has been shown by Parker to be the recognition of water vibrations of low frequency, slower than the lowest sound waves audible to the human ear. They are probably also concerned with equilibration. The semicircular canals of the labyrinth as in the human body, are the chief organs of the equilibratory and static functions, while the sense organs of the sacculus of fishes are concerned with true hearing. There is no cochlea and the auditory sense is doubtless very simple with no capacity for tone analysis. All of these sense organs have the same fundamental structure and all are excited by movements in the fluid into which the hairs of the hair cells project. They are doubtless derived from a common type of simple cutaneous tactile sense organ.

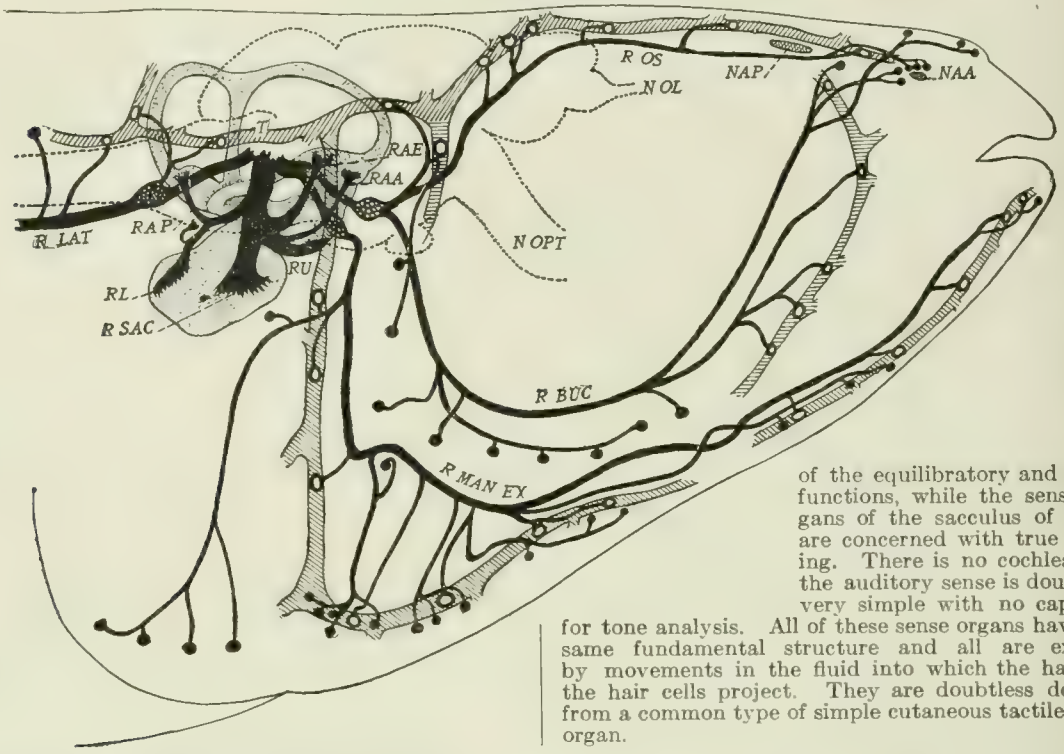


Fig. 1800.—The Acustico-lateral System of Nerves with Their Peripheral End Organs, as Seen from the Right Side, in the Silver Side, *Menidia*. Reconstructed from serial sections by projection upon the sagittal plane. ×12. The dotted outline represents the position of the brain, the lateral-line canals are shaded with cross-hatching, the auditory labyrinth is stippled, and the nerves are drawn in black. The organs of the lateral-line system are drawn as black discs when naked on the surface of the skin, and as black circles when lying in the canals. For the relation between the acustico-lateral nerves and the other systems of nerves in this fish, see the more detailed plot from which this was drawn off, in the *Journal of Comparative Neurology*, vol. ix., plate xv., or the *Archives of Neurology and Psychopath.*, vol. ii., plate ii. *NAA*, anterior nasal aperture; *NAP*, posterior nasal aperture; *NOL*, olfactory nerve; *N OPT*, optic nerve; *RAA*, ramulus acusticus ampullæ anterioris; *RAE*, ramulus acusticus ampullæ externæ; *RAP*, ramulus acusticus posterioris; *R BUC*, ramus buccalis facialis; *RL*, ramulus acusticus lagenæ; *R LAT*, ramus lateralis vagi; *R OS*, ramus ophthalmicus superficialis facialis; *R MAN EX*, ramus mandibularis externus facialis; *R SAC*, ramulus acusticus sacculi; *RU*, ramulus acusticus recessus utriculi; *T*, tuberculum acusticum.

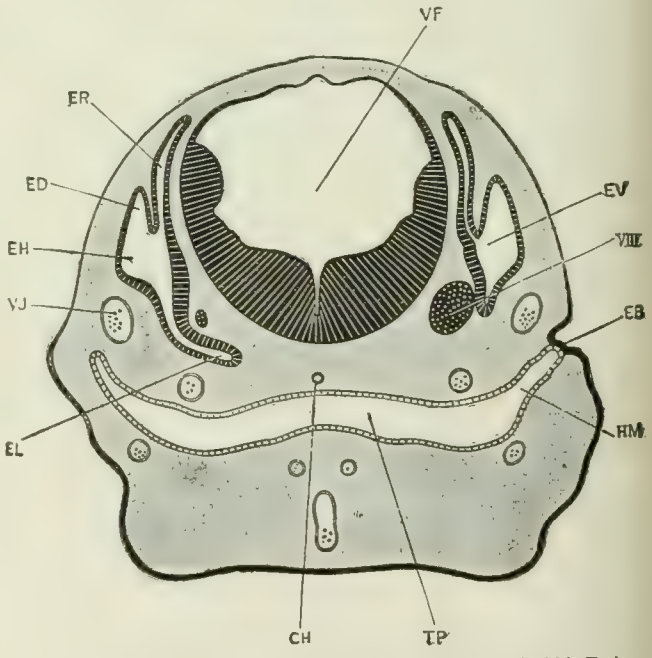


Fig. 1801.—A Transverse Section Across the Head of a Rabbit Embryo at the End of the Eleventh Day. The plane of the right half of the figure is slightly anterior to that of the left half. × 30. From Marshall's "Embryology." *CH*, notochord; *EB*, membrane closing the hyomandibular cleft; *ED*, common stem of the two vertical semicircular canals; *EH*, rudiment of the external semicircular canal; *EL*, cochlear canal; *ER*, recessus vestibuli; *EV*, auditory vesicle; *HM*, hyomandibular pouch; *TP*, pharynx; *VF*, fourth ventricle; *VJ*, jugular vein; *VIII*, auditory nerve.

The lateral-line organs are found in aquatic animals only (fishes and amphibians). The semicircular canals change very little, either in structure or function, from the lowest to the highest vertebrates, and the same is true of the large sensory spots in the sacculus and utriculus. The fishes, however, possess a macula lagenæ in the sacculus which resembles the other sensory areas of the vestibule, but which in the course of further evolution undergoes a remarkable transformation, becoming the organ of Corti of the cochlea in mammals. Parallel with the evolution of the organ of Corti in land animals, for the analysis of tone, the sound-transmitting apparatus of the middle ear is elaborated.

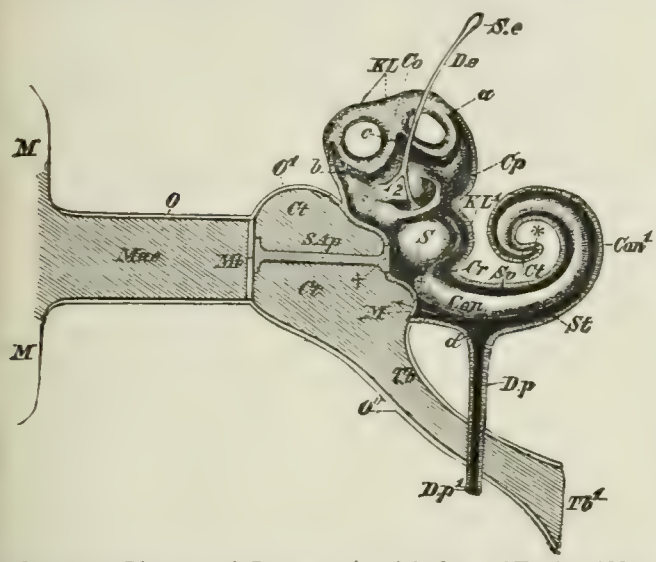


Fig. 1802.—Diagrammatic Representation of the Organ of Hearing of Man. (After Wiedersheim.) *Outer ear*—*M*, *M*, auricle; *Mae*, meatus auditorius externus; *O*, its wall; *Mt*, membrana tympani. *Middle ear*—*Ct*, *Ct*, cavum tympani; *O*¹, its wall; *SAp*, sound-conducting apparatus, which is drawn as a simple rod-like body instead of the auditory ossicles; the place † corresponds to the stapedial plate, which closes the fenestra ovalis; *Tb*, Eustachian tube; *Tb*¹, its opening into the pharynx; *O''*, its wall. *Inner ear*—The bony labyrinth, *KL*, *KL*¹, for the most part cut away; *S*, sacculus; *a*, *b*, the two vertical semicircular canals, of which one (*b*) is cut through; *S.e*,*D.e*, saccus and ductus endolymphatics, of which the latter is divided at 2 into two arms; *Cp*, cavum perilymphaticum; *Cr*, canalis reuniens, *Con*, membranous cochlea, which produces at * the vestibular cæcum; *Con*¹, bony cochlea; *Sv* and *St*, scala vestibuli and scala tympani, which at * communicate with each other at the cupula terminalis (*Ct*); *D.p*, ductus perilymphaticus, which arises from the scala tympani at *d* and opens out at *D.p*¹. The horizontal semicircular canal is not especially designated.

The lagena already present in the fishes' labyrinth.

The middle and external ear do not appear in the fishes, the vibrations of the surrounding medium being transferred to the labyrinth through the tissues of the head. But air-breathing vertebrates require some intermediary mechanism to intensify the more feeble aërial vibrations. Accordingly, the middle ear, with its contained auditory ossicles, is seen for the first time in the Amphibia. The phylogeny of the auditory ossicles has been the subject of endless investigation, and there is still no agreement upon the details of this history. The internal ear in the lower fishes clearly lies in the hyoid segment of the head.

The Eustachian tube is now regarded as the derivative of the spiracular canal, a rudimentary gill cleft present in some of the lower fishes between the hyoid and mandibular arches. In the mammals this tube never quite reaches the surface of the head, but is cut off by an epithelial membrane composed of a layer of ectoderm and a layer of entoderm (*EB*, Fig. 1801), with an intervening layer of mesoderm appearing in later developmental stages. This membrane becomes the tympanic membrane, the portion of the tube within it the Eustachian tube, and the pit leading from it to the surface the external auditory meatus (Fig. 1802).

These alterations in the relative importance of the different members of the acustico-lateral complex are naturally reflected in the central nervous system. We therefore find that the size of the acustico-lateral centers (area acustica and cerebellum) in the fishes is directly proportional to that of the peripheral organs of this system. With the development of a cochlea in the mammals, an entirely new set of connections is effected in the oblongata, which are by no means so closely related to the cerebellum as are the end stations of the vestibular root. These are the ventral and dorsal cochlear nuclei. In connection with the fact that the secondary fibers connected with the cochlear root terminate very largely in the inferior member of the corpora quadrigemina (see below), it is interesting to note that this body appears upon the surface of the brain in the phylogeny contemporaneously with the cochlea. The cerebellum has been mentioned as a secondary end station for the acustico-lateral system of nerves. As the organ of equilibration (and of the static senses in general) for the body, this was probably its primary connection. But these static functions are served by all of the other senses as well (except, perhaps, the olfactory), so that the terminal nuclei of the other sensory nerves have also effected secondary connections with the cerebellum.

Embryology.—The auditory organ first appears in early embryos before the neural tube is closed, as a lateral ectodermal thickening. In animals in which the ectodermal epithelium at this stage is simple, the whole epithelium of the auditory plate invaginates to form the "auditory saucer," and later a vesicular sac which sinks down below the surface. But in other cases, in which the ectoderm becomes earlier two layered, it is only the inner, or nervous layer, which participates in this invagination, and the auditory vesicle never communicates with the surface of the body (Fig. 1803).

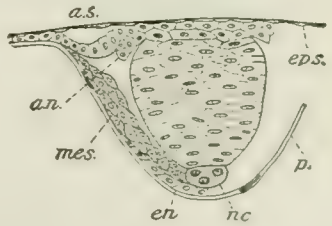


Fig. 1803.—Transverse Section through the Head of an Embryo of the Sea Bass of Thirty-five Hours. (After H. V. Wilson.) *a.n.*, Auditory nerve; *a.s.*, auditory saucer; *en*, entoderm; *ep.s.*, epidermic stratum of ectoderm; *mes.*, mesoderm; *nc.*, notochord; *p.*, periblast. The large oval mass of cells in the center of the figure is the medulla oblongata.

The auditory saucer, whether formed from the whole of the ectoderm or only from its inner layer, soon

closes up and withdraws from the skin to form the auditory vesicle. In the elasmobranch fishes the vesicle retains its primary connection with the outer surface of the body to adult life by means of a slender tube, the ductus endolymphaticus, in this point

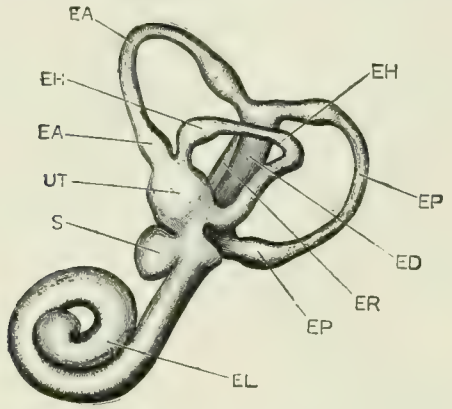


Fig. 1804.—The Left Auditory Vesicle of a Human Embryo of the Eighth Week, Seen from the Left Side. (After W. His, Jr., from Marshall's "Embryology." ×17. *EA*, Anterior vertical semicircular canal; *EA'*, ampulla of anterior vertical semicircular canal; *ED*, common stem of the two vertical semicircular canals; *EH*, horizontal semicircular canal; *EH'*, ampulla of horizontal semicircular canal; *EL*, cochlea; *EP*, posterior vertical semicircular canal; *EP'*, ampulla of posterior vertical semicircular canal, *ER*, recessus labyrinthi; *S*, sacculus; *UT*, utriculus.

resembling the lateral line canals, which open freely to the surface by means of a series of pores. But in all of the higher animals this connection is lost, though the tube persists as a blind pouch, the saccus and ductus endolymphaticus (Fig. 1802, *D.e.*, and

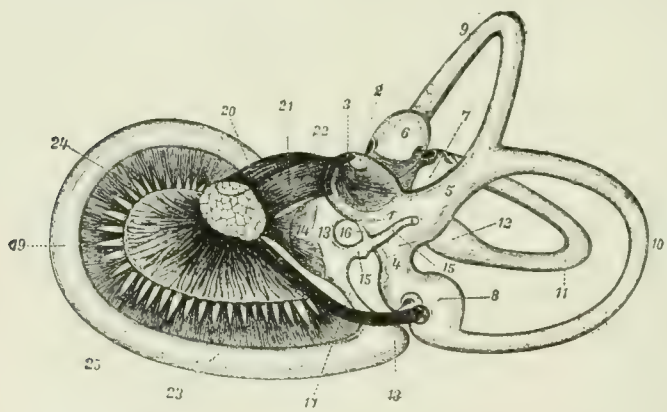


Fig. 1805.—The Membranous Labyrinth of the Right Internal Ear of a Human Embryo at the Fifth Month, Seen from the Medial Side. (After Retzius, from Barker's text-book.) 1–5, Utriculus; 2, recessus utriculi; 3, macula acustica utriculi; 4, sinus posterior; 5, sinus superior; 6, ampulla membranacea superior; 7, ampulla membranacea lateralis; 8, ampulla membranacea posterior; 9, ductus semicircularis superior; 10, ductus semicircularis posterior; 11, ductus semicircularis lateralis; 12, widened mouth of crus simplex of the lateral semicircular canal opening into the utriculus; 13, sacculus; 14, macula acustica sacculi; 15, ductus endolymphaticus; 16, ductus utriculo-saccularis; 17, ductus reuniens; 18, cecum vestibulare of ductus cochlearis; 19, ductus cochlearis; 20, nervus facialis; 21–24, N. acusticus; 21, N. vestibuli; 22, N. saccularis; 23, N. ampullaris inferior; 24, N. cochleæ; 25, distribution of N. cochleæ within the lamina spiralis ossea.

Fig. 1805, 15), which joins the membranous labyrinth at the ductus utriculosaccularis.

The auditory plate is the most highly differentiated member of the series of suprabranchial placodes (cf. *Cranial Nerves*). In fishes similar preauditory and postauditory placodes give rise to a part (sometimes to all ?) of the ganglia of the lateral-line nerves (Landacre).

The primitive pear-shaped auditory vesicle in early human development is divided into a small vestibular pouch and a larger cochlear pouch. The vestibular pouch becomes separated into saccular and utricular portions and from the latter the semicircular canals are pinched off. The form of the membranous labyrinth in a human embryo of the eighth week is shown in Fig. 1804 and of the fifth month in Fig. 1805. The adult relations are diagrammatically indicated in Fig. 1806.

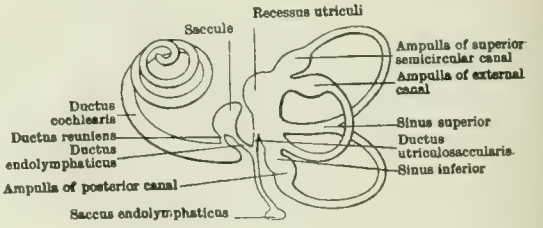


Fig. 1806.—Diagrammatic Representation of the Different Parts of the Membranous Labyrinth. (Cunningham.)

While the auditory vesicle is still in a quite undifferentiated condition, its lining epithelium develops a patch of sensory cells which enlarges very irregularly in such a way that during the subsequent plications of the walls of the vesicle each of the chambers thus evaginated (except the endolymphatic duct) receives a portion of this modified epithelium. These patches now become separated by non-sensory pavement epithelium and constitute the three cristæ in the ampullæ of the semi-circular canals, the maculæ of the utriculus and sacculus and the organ of Corti of the cochlea.

The auditory vesicle, which is primarily ectodermal, at first lies simply embedded in the surrounding mesoderm (Fig. 1801). A portion of this mesoderm is added to the vesicle, and thus the definitive membranous labyrinth is formed from both of these germ layers. The enveloping cartilages—which become, when ossified, the bony labyrinth—develop a short distance removed from the membranous labyrinth, and the intervening mesoderm is dissolved, leaving the perilymphatic spaces between the membranous and the bony labyrinth. The scala tympani and the scala vestibuli are the continuations of these spaces into the cochlea, while the scala media is the only part of the cochlea which is lined by a derivative from the original ectodermal auditory vesicle. Accordingly, the organ of Corti is developed in the floor (membrana basilaris) of the scala media.

The origin of the VIII ganglia has been variously described. Its cells probably are proliferated wholly or in part from the auditory vesicle at a very early stage. The ganglion is so on divided into two parts which retain their independence throughout life, the vestibular and the spiral or cochlear ganglion (Fig. 1807). In their further development these ganglia pursue very different courses, the cells of the vestibular ganglion being distributed along the course of their nerve. while those of the cochlear ganglion remain throughout life at the distal end of their nerve in the cochlea. The cochlear and vestibular nerves, moreover, remain distinct to a late developmental period. It has been customary, following Retzius and His, Jr., to describe the ramus vestibularis as supplying the utricle and the superior and lateral ampullæ, and the ramus cochlearis

as supplying the saccule the posterior ampulla and the cochlea. More recent work (Cannieu, Alexander, Streeter) has emphasized the anatomical as well as the physiological independence of the cochlear nerve, the

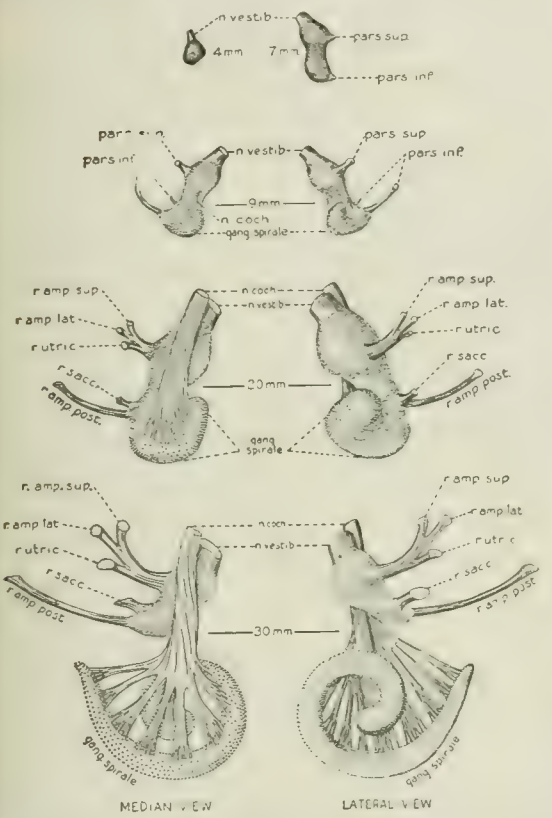


Fig. 1807.—Stages in the Differentiation of the Acoustic Nerve Complex. The vestibular ganglion is shown by fine dots, the spiral ganglion by large dots. (After Streeter.)

nerves of the saccule and posterior ampulla belonging to an inferior ramus of the vestibular nerve, as indicated below:

| | | |
|---|---|---|
| n. vestibularis | pars superior | r. ampul. sup. |
| | | r. ampul. ext. |
| | | r. recess. utric. |
| | pars inferior | r. sacculoris |
| | | r. ampul. post. |
| n. cochlearis. . . | ramuli spirali | |

The Auditory or Acoustic Nerve.—The intimate association of nerves and end organs serving so diverse functions in the internal ear is explained, as above suggested, by their common phyletic origin from a much more generalized somatic sensory system. The physiological separateness of the sense of hearing, on the one hand, and the equilibratory and static reflexes, on the other hand, is very evident. Similarly, the peripheral receptive organs of the cochlea are in mammals quite distinct from those of the vestibule and labyrinth, and the central connections of the cochlear and vestibular nerves are fundamentally different. The vestibular nerve terminates in reflex centers of the oblongata and cerebellum with no important cortical connections, while the cochlear nerve has, in addition to important reflex connections in the oblongata, the much stronger ascending pathway in the lateral lemniscus to the inferior colliculus, medial geniculate body and cortex (cf. *Brain, Anatomy*). Nevertheless the fact that fishes undoubtedly hear, notwithstanding their lack of cochlea or any other receptors more complex than the sensory spots in the saccule, demonstrates the relatively late phylogenetic origin of the cochlear system from the vestibular, and has suggested to some physiologists that even in man these two systems are not wholly distinct. Support for the latter idea has been sought from the intimate relations existing between the cochlear nerve and the nerve of the saccule and posterior ampulla. But the demonstration of the complete anatomical independence of the cochlear nerve in development (Streeter) and in the adult leaves small basis for this contention.

The nervus vestibularis, in the wider sense in which this term is here employed, supplies the three ampullary sense organs and the sensory maculæ of the utriculus and sacculus. These sense organs are simple sensory epithelia, in fundamental structure resembling each other and also the sense organs of the lateral lines of fishes (Fig. 1799). The supporting cells of these organs constitute a simple columnar epithelium. Among these cells are the shorter hair cells, or specific sensory cells, extending only part of the distance through the thickness of the epithelium; their relations to the termini of the nerve are shown in Fig. 1808.

The hairs which arise from the free surfaces of the specific sensory cells do not float free in the endolymphatic fluid, but are embedded in a semi-gelatinous substance within which small particles of calcium carbonate, the otoliths, are also found (otolithic membrane, cupula).

The cupula of the ampullary sense organs (cristæ) is described by Shambaugh (1912) as a cap firmly fixed upon the crista, not as a movable structure as sometimes stated. The hair cells are stimulated by an interaction between the hairs and the cupula occasioned by the impact of the endolymphatic fluid against the sides of the cupula, different groups of hair cells being excited according to the direction of flow of the endolymph. The hair cells on one side of the cupula are more easily excited than are those on the opposite side, for the reaction which follows upon stimulation by one direction of endolymphatic flow is greater than that arising from the flow in the opposite direction. This peculiarity has an important bearing upon the interpretation of the phenomena of nystagmus of labyrinthine origin (for the details of which see the paper by Shambaugh cited).

Fig. 1808.—Scheme of the Peripheral Termination of the Nervus Vestibuli. (After Retzius, from Barker's text-book.) *co*, Central nervous system; *fz*, supporting cell; *hz*, hair cells; *sn*, neurite of N. vestibuli; *sz*, cell body of vestibular neurone.

The fibers of the vestibular nerve arise from ganglion cells lying in the course of the nerve, the vestibular ganglion or ganglion of Scarpa. These cells, like all others connected with the nerves of the internal ear (and the lateral, line nerves of fishes as well), remain bipolar throughout life in all animals. The method of the termination of the peripheral processes about the specific cells of the sensory spots has already been illustrated. The central processes form the vestibular (medial or anterior) root of the eighth nerve. It enters the brain ventrally and cephalad of the cochlear root and passes

dorsad between the fibers of the restiform body and the spinal V tract.

The central relations of the nervous pathways concerned in nystagmus of labyrinthine origin have been studied by Wilson and Pike (1912), who have shown that such nystagmus in the dog and cat consists of two phases—a slow deviation followed by a quick return—varying definitely in direction with the labyrinth which is stimulated or destroyed. These phases are distinct. The slow deviation is a function of the vestibulo-oculomotor apparatus in the medulla oblongata and mid-brain and is unmodified by removal of the cerebral hemispheres and thalamus. The quick phase of nystagmus, on the other hand, is a function of the cerebrum.

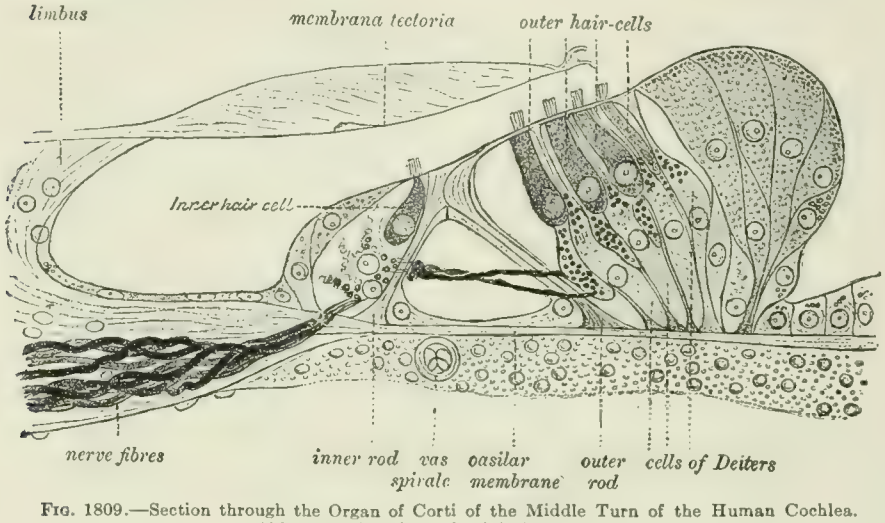


Fig. 1809.—Section through the Organ of Corti of the Middle Turn of the Human Cochlea. (After Retzius, from Quain's "Anatomy.")

The cell bodies from which the fibers of the cochlear nerve arise lie chiefly (if not wholly) in the spiral ganglion, or ganglion of Corti, in the axis of the bony cochlea. The peripheral processes of these ganglion cells terminate in the organ of Corti. The central processes constitute the cochlear (lateral or dorsal) auditory root. In the embryological development they become medullated somewhat later than those of the vestibular root, a feature to be correlated with the fact that this nerve appears in the phylogeny at a later period than the vestibular nerve.

All of the fibers of the cochlear nerve appear to enter the ventral or the dorsal cochlear nucleus either to terminate in them or to pass through them. The ventral nucleus is often spoken of as accessory nucleus, and is thought by Sala and Onufrowics to contain some of the ganglion cells of the peripheral auditory neurones. The dorsal nucleus is the tuberculum acusticum of human anatomy.

The Organ of Corti.—The specific sensory area which develops in the embryonic cochlear pouch becomes much more complex than do the other sense organs of the internal ear. The generally accepted structure of this organ of Corti, as presented in the classical researches of Retzius, is shown in Fig. 1809. Upon a basement membrane of mesodermal origin is a very highly differentiated sensory epithelium, part of whose cells are supporting elements of diverse sorts and part (the hair cells) are specific receptors. The termini of the cochlear nerve arborize around the bodies of the hair cells in the same way that fibers of the vestibular nerve are related to the hair cells of the maculæ and cristæ of the labyrinth (Fig. 1808). The membrana tectoria occupies the position of the cupula of the crista ampullaris and is intimately connected with the hairs of the hair cells. Its shape has been very carefully studied by Hardesty.

Many details of the structure of the organ of Corti, or spiral organ, and the whole question of the mode of its functioning are still controverted. Our present knowledge of the histological organization of the basilar membrane shows that it is structurally incapable of serving the function of tone analysis in the way postulated by Helmholtz's theory. Based upon important additions to our knowledge of the minute structure of the organ of Corti and clinical observations upon diseased conditions, several different theories of the mechanism of tone analysis have recently been expressed. The most important of these researches are those of Shambaugh. This author has demonstrated that the hairs of the hair cells do not terminate freely in the endolymph, as commonly figured, but that they are firmly attached to the under surface of the tectorial membrane. This membrane has a semi-gelatinous texture and is capable of taking up sympathetically the vibrations of the endolymph within which it floats.

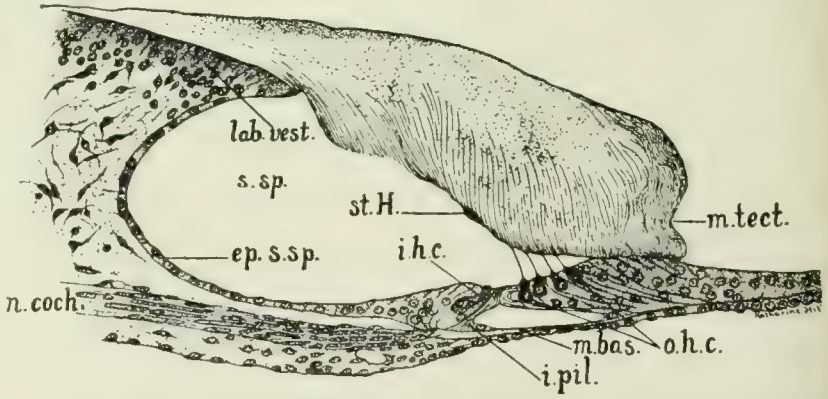


Fig. 1810.—Section through the Apical Turn of the Cochlea of the Pig at about Full Term, showing outer auditory hairs imbedded in the membrana tectoria. *ep.s.sp.*, Epithelium of spiral sulcus; *i.h.c.*, inner hair cells; *i.pil.*, inner pillar; *m.bas.*, basal membrane; *m.tect.*, membrana tectoria; *lab.vest.*, labium vestibulare; *n.coch.*, cochlear nerve; *o.h.c.*, outer hair cell; *s.sp.*, sulcus spiralis; *st.H.*, Hensen's stripe. (After C. W. Prentiss.)

The development of the tectorial membrane has recently been restudied by Prentiss, who finds that it first appears as a thin cuticular plate developed

over the free ends of the columnar cells which form the inner epithelial thickening of the basal cochlear wall. Since it is present before the appearance of hair cells in the spiral organ, it cannot be regarded as developed from these hairs. The membrane grows in thickness by the secretion of a cuticulum formed between the ends of the epithelial cells, thus giving to the mature membrane a chambered or honeycomb structure. The attachment of the membrane to the spiral organ was confirmed, not only by sections but by dissections of fresh and fixed cochleæ (Fig. 1810). The membrana tectoria, then, is a delicate chambered cuticular structure, coextensive with the spiral organ. It is attached by its inner zone to the labium vestibulare, by its outer zone between the cells of the spiral organ, thus bridging over the spiral sulcus. Its sectional area at base and at apex is as 1:40 approximately. As the hairs of the auditory cells project directly into the chambers of the membrana, vibrations of the membrana would be directly transmitted to them.

Shambaugh concludes that the tectorial membrane takes the part of a physical resonator by responding in its various parts to tones of different pitch, depending on the size of the membrane, tones of higher pitch being taken up by the hair cells located near the beginning of the basal coil, those of lower pitch by the cells near the apex of the cochlea, where the tectorial membrane attains its maximum size. The stimulation of the hair cells is effected only through the medium of their projecting hairs, these being excited by vibrations of the tectorial membrane to which they are attached.

C. Judson Herrick.

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**Ear: Anatomy of the Auricle.**—The auricle or pinna forms with the auditory canal or meatus the external ear. It is placed on the side of the head about midway between the external angle of the eye and the occipital protuberance; the upper border is about on a level with the eyebrow; the lower edge of the lobe is about on a level with the tip of the nose. Its vertical line is parallel to the ramus of the jaw and forms an angle of about 100 or 105 degrees with the horizontal plane of the head. Those ears in which this angle exceeds 112 degrees are called slanting ears. In height the auricle measures from 55 to 60 millimeters, and in width from 25 to 35 millimeters. The height of the auricle is generally found to be equal to the length of the nose. The true length of the auricle varies in man from 22 to 49 millimeters, the average being 35.9 millimeters; in woman it varies from 24 to 41 millimeters, the average being 33.7 millimeters. The true width* of the auricle varies in man from 33 to 58 millimeters, the average being 44.4 millimeters, while in woman it varies from 30 to 61 millimeters, the average being 40 millimeters. The anterior third of the auricle is firmly attached to the root of the zygoma and to the squamous and mastoid surfaces of the temporal bone by means of ligamentous, muscular, and cutaneous tissues. The posterior two-thirds is free and is placed so as to form with the lateral surface of the head the cephalo-auricular angle which, opening backward, measures on an average from 30 to 40 degrees, and may vary between 0 and 90 degrees; the angle decreasing in size as it passes upward and forward.

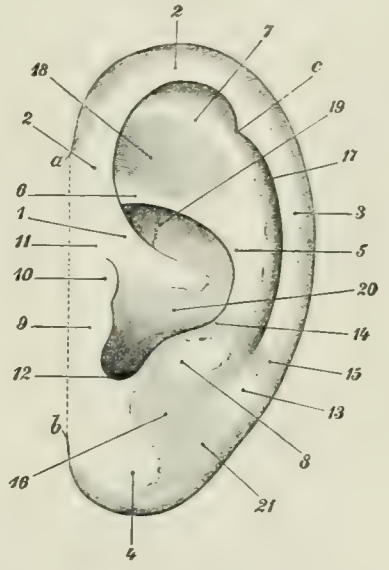


Fig. 1811.—Auricle of a Man. (After Schwalbe.) *ab*, Base of the auricle; *abc*, triangle of the auricle; *c*, Darwinian point or tubercle; 1, crus helicis; 2, 2, ascending (anterior upper) portion of the helix; 3, descending (posterior) portion of the helix; 4, lobule; 5, main portion of the antihelix; 6, crus inferius anthelicis; 7, crus superius anthelicis; 8, antitragus; 9, tragus; 10, tuberculum supratragicum; 11, sulcus auris anterior (incisura trago-helicina); 12, incisura intertragica; 13, tuberculum retrolobulare of His; 14, sulcus auris posterior (incisura anthelicis); 15, sulcus helicolobularis; 14+15, sulcus obliquus of His; 16, sulcus supralobularis; 17, fossa navicularis or scaphoidea; 18, fossa triangularis; 19, cymba conchæ; 20, cavitas conchæ; 21, sulcus retrolobularis.

The *framework* of the auricle consists of convoluted folds of yellow reticulated cartilage, from 1 to 2 millimeters in thickness, and is covered by its perichondrium. It supports the glandular, vascular, muscular, and cutaneous tissues of the auricle. The cartilage does not enter into the construction of the lobule and is deficient between the tragus and the spina helicis.

The auricle may be considered to be an expansion of the external auditory canal, which it surrounds, and especially so above and behind. It is oval in form, with the longest axis vertical and its broadest

* The terms "true length" and "true width" are explained further on.

extremity above. It has two surfaces—an external and an internal—and a circumferential border. The external surface looks obliquely outward, forward, and slightly downward. It is so folded upon itself that it presents a number of elevations and depressions, which give it a most irregular and characteristic appearance. The outer surface is as a whole concave, while the inner is convex, and the depressions and elevations of one surface correspond in a general way to the elevations and depressions of the other.

The border of the auricle—that is, the upper third of the anterior portion, all of the superior portion, and the upper two-thirds of the posterior portion—is rolled in upon itself and forms the most prominent elevation or crest on the external surface of the organ. It is called the *helix* (Fig. 1811, 1, 2, 3). It begins in a thin root, the *crus helicis* (Fig. 1811, 1), in the cavity of the concha, and passes obliquely upward and forward, and then in a semicircle upward, backward, and downward, to terminate in a free extremity, the *processus helicis caudatus* (Fig. 1812, 2), at the *sulcus helicolobularis* (Fig. 1811, 15). The *crista helicis* divides the concha into two parts—the upper and smaller, the *cymba conchæ* (Fig. 1811, 19), and the lower and larger, the *cavitas conchæ* (Fig. 1811, 20), which is continuous with the external auditory canal. By the incurving of the helix a groove is formed beneath it—the *fossa of the helix*. This groove is well marked in its ascending portion, and gradually becomes shallow as it passes backward and downward. A small spine, the *spina helicis* (Fig. 1812, 1), is given off from the ascending portion of the helix. It serves to give a firm attachment to the attrahens auriculum muscle. This spine, as well as the *processus caudatus helicis*, is to be seen only when the cartilage is denuded of its coverings. At the junction of the horizontal portion of the helix with the descending portion we have a tubercle known as the *Darwinian point* or *tubercle* (Fig. 1811, *c*), which possesses much morphological importance, as will be shown below. It corresponds to the ear tip of animals.

A second eminence or crest, the *antihelix* (Fig. 1811, 5), begins, in the upper anterior portion of the fossa helicis, in two converging crests, the *crura furcata*, or the *crus inferius anthelicis* (Fig. 1811, 6) and the *crus superius anthelicis* (Fig. 1811, 7). It passes downward and backward in front of the descending portion of the helix. The depression which is formed between the two crests is known as the *fossa navicularis* or *fossa scaphoidea* (Fig. 1811, 17). The depression between the crura furcata is called the *fossa intercruralis* or *triangularis* (Fig. 1811, 18). The antihelix is separated, by the sulcus auris posterior (incisura anthelicis, Fig. 1811, 14), from a rounded eminence—the *antitragus* (Fig. 1811, 8), and in front of this eminence, and separated from it by that portion of the cavity of the concha which is called the *incisura intertragica* (Fig. 1811, 12), is a lid-like covering to the auditory canal—the *tragus* (Fig. 1811, 9). It is separated from the root of the helix by the *sulcus auris anterior* or *incisura tragohelicina* (Fig. 1811, 11).

The most dependent part of the auricle, which is devoid of cartilage and is made up principally of connective and adipose tissues, is called the *lobe* (*lobulus auricularis*) (Fig. 1811, 4).

On the inner surface the elevations, as they correspond to the depressions on the outer surface, have received similar names, and are known consequently as the *eminentia fosssæ caphoideæ vel triangularis* (Fig. 1812, 7); the *eminentia fossæ navicularis* (Fig. 1812, 11); and the *eminentia conchæ* (Fig. 1812, 8). From the posterior inferior border of the latter eminence arises a crest, the *ponticulus* (Fig. 1812, 10), which passes obliquely downward and forward to the *incisura terminalis* (Fig. 1812, 12); and to this crest is attached the retrahens auriculum muscle.

In a like manner the following names have been given to the depressions on the inner aspect of the auricle: the *fossa anthelicis*, (Fig. 1812, 5); the *sulcus anthelicis transversus* (Fig. 1812, 6); the *sulcus cruris helicis* (Fig. 1812, 9); and the *fissura antitrago-helicina* (Fig. 1812, 13).

To aid in holding the cartilaginous folds in place and in uniting the auricle to the head, two sets of *ligaments* are provided—the intrinsic and the extrinsic.

The *intrinsic ligaments* are four in number: two are on the inner surface of the auricle and unite the em-

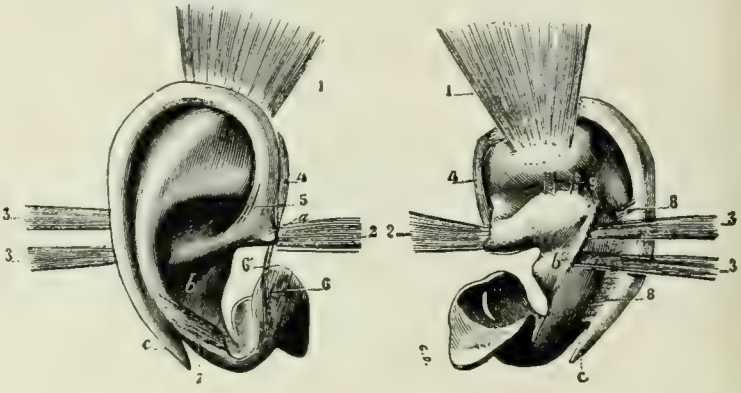


Fig. 1813.—Muscles of the Auricle; A, as Seen on the External Surface; B, as Seen on the Internal Surface. 1, The attolens auriculum or musculus auricularis superior; 2, the attrahens auriculum or musculus auricularis anterior; 3, 3, the retrahens auriculum, or musculus auricularis posterior; 4, the helicis major; 5, the helicis minor; 6, the tragicus, with 6′, its accessory fasciculus; 7, the antitragicus; 8, the transversus auricular; 9, the obliquus auriculæ; *a*, spina helicis; *b*, concha, with *b′* its posterior thickening or ponticule; *c*, spina caudatus helicis. (After Testut.)

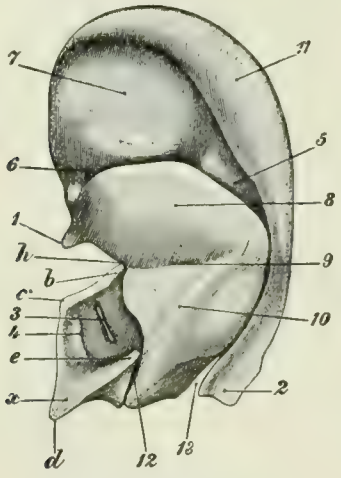

Fig. 1812.—Cartilaginous Framework of the Human Auricle (Inner Surface). (After Schwalbe.) *bc*, Upper border of the cartilaginous furrow for the blood-vessels; *cd*, anterior medial border; *de*, posterior medial border; *x*, processus triangularis; *h*, angle of the anterior margin of the concha; 1, spina helicis; 2, processus helicis caudatus; 3, lateral bipartite Santorinian incisura; 4, medial Santorinian incisura; 5, fossa anthelicis; 6, sulcus anthelicis transversus; 7, eminentia fossæ triangularis; 8, eminentia conchæ; 9, sulcus cruris helicis; 10, ponticulus; 11, eminentia fossæ navicularis; 12, incisura terminalis; 13, fissura antitrago-helicina.

inentia conchæ with the eminentia triangularis, and also with the eminentia fossæ navicularis. The other two are on the outer surface. One unites the antitragus with the processus caudatus helicis and the antihelix, and so fills in the sulcus auris posterior. The fourth extends from the tragus to the helix, and gives off a fasciculus which is inserted in the external auditory canal. It in great measure fills up the incisura intertragica.

The *extrinsic ligaments* are: the anterior, divided into a superior and an inferior fasciculus, which extend from the root of the zygoma to the tragus and to the spina helicis; the posterior, which extends from the mastoid process to the posterior surface of the concha; and, finally, a fasciculus which extends into the external auditory canal.

The *muscles* of the auricle are also divided into the intrinsic and the extrinsic group. The first group consists of: I., the *helicis major* (Fig. 1813, 4), which extends from the spina helicis to the ascending portion of the helix and the integument covering it; II., the *helicis minor* (Fig. 1813, 5), which extends from the root of the helix to the ascending portion of the helix; III., the *tragicus*, a quadrilateral bundle of fibers attached to the external surface of the tragus by two sets of fibers—one of them running laterally and another vertically, while a small bundle of the latter extends to the spina helicis (Fig. 1813, 6, 6′); IV., the *antitragicus*, which passes from the antitragus upward and backward to the antihelix and the helix near the spina caudatus helicis (Fig. 1813, 7); V., the *transversus auriculæ*, which extends on the inner surface of the auricle from the lower portion of the eminentia navicularis to the eminentia conchæ (Fig. 1813, 8); VI., the *obliquus auriculæ*, which consists of two or three fasciculi and extends from the eminentia fossæ triangularis to the eminentia conchæ (Fig. 1812, 9).

In man these muscles are merely rudimentary, while in animals they serve, first, to modify the general form of the auricle so as to allow, at pleasure, the manner and the amount of force with which the sound waves are reflected toward the auditory canal; second, to modify the dimensions of the entrance to the auditory canal, so as to influence the amount of sound

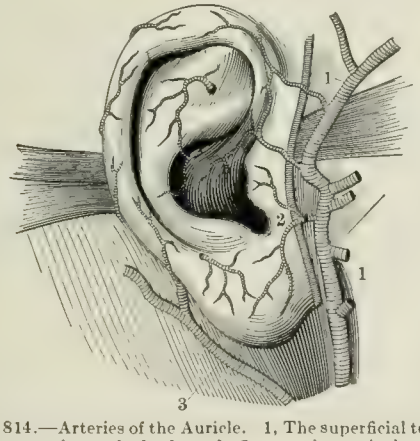


Fig. 1814.—Arteries of the Auricle. 1, The superficial temporal; 2, inferior anterior auricular branch; 3, posterior auricular. (After Testut.)

which is to penetrate to the membrana tympani. The muscles of the tragus and the antitragus are the constrictors, and the muscles of the helix are the dilators, of the external auditory canal.

The second or extrinsic group of muscles of the auricle comprises: I., the *attollens auriculum*, or *musculus auricularis superior*, which arises from the epicranial aponeurosis, passes downward with fibers converging, and is inserted into the eminentia triangularis (Fig. 1813, 1); II., the *attrahens auriculum*, or *musculus auricularis anterior*, which also arises from the cranial aponeurosis above the zygoma, passes backward, and is inserted into the spina helicis (Fig. 1813, 2); III., the *retrahens auriculum*, or *musculus auricularis posterior*—a muscle which is composed of two or three fasciculi that arise from the mastoid process, pass forward, and are then inserted into the ponticulus (Fig. 1813, 3). These muscles are also for the most part rudimentary in man, but when they are capable of voluntary action, the first draws the auricle upward, the second forward and upward, and the third backward. In animals these muscles serve the important function of directing the auricles toward the source of the sound.

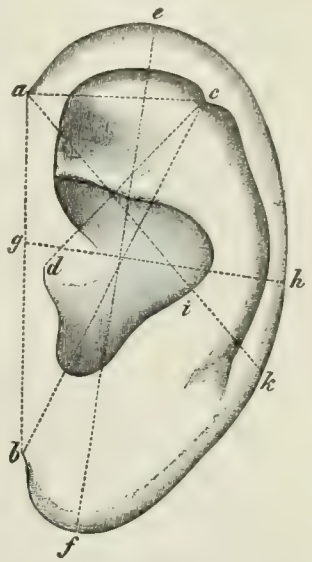


Fig. 1815.—Diagram of the Human Auricle, Showing Its Chief Dimensions. (After Schwalbe.) *ab*, Base of the auricle, true breadth; *cd*, true length of the auricle; *ef*, maximum length; *gh*, maximum breadth; *acb*, triangle of the auricle. The line *ak*, is the dividing line between the region of the auricular eminences (*aikfb*) and that of the free fold (*aikce*).

The *skin* which covers the auricle, except for its greater delicacy, is of the same general construction as that of the surrounding region, with which it is continuous. Owing to a greater development of its subcutaneous connective tissue on the external surface of the auricle, it is more firmly attached to it than on the inner surface. Except in the lobe of the ear it is destitute of fat; on the other hand, it is well supplied with lymphatics, especially so on its inner surface. The *sebaceous glands* scattered over the surfaces of the auricle are found more numerous in the concha and in the fossa triangularis. *Sudoriferous glands* are also to be found on the surfaces of the auricle.

The *arteries* which supply the auricle are derived from the superficial temporal (Fig. 1814, 1), and the posterior auricular (Fig. 1814, 3), both of them branches of the external carotid. From the first are derived the *superior anterior*, the *middle anterior*, and the *inferior anterior auricular* branches, which supply the anterior portion of the external surface of the auricle (Fig. 1814, 2). From the second are derived the *posterior auricular* branches, three or four in number, which supply the posterior two-thirds of the auricle, both on its inner and on its outer surface. These arteries are divided into two sets of branches, one set of which pass superficially on the inner surface of the auricle to its border and thence over it to the outer surface, while the other set penetrate through from the inner surface to the outer and furnish the blood supply for the structures of the concha, the antihelix, and the lobule (Fig. 1811, 4, 5). Free anastomosis takes place between all of these various branches.

The surface of the auricle is almost everywhere covered with fine soft lanugo hairs, but in the region of the meatus and of the tragus and antitragus, there are apt to be—especially later in life—some very stiff and wiry hairs.

The *nerves* are of two kinds, the sensory and the motor; the latter being derived from the facial and the former from the auricular temporal branch of the inferior maxillary, and also from the temporo-auricular branch of the superficial cervical plexus.

The TRUE AURICLE is to be found only in the mammalia. The movable fold of skin which covers the opening to the auditory canal of such animals as the crocodile is by no means homologous with the auricle of the mammalia; a greater likeness is to be seen in the movable flap of skin to be found in such birds as the owl. On the other hand, the auricle of man is but poorly developed when compared with that of most animals, *e.g.* the kangaroo, the rabbit, the hare, the carnivora, in all of which the auricle is very highly developed, while in the long-eared bat of Britain the surfaces of both auricles are together equal to the entire surface of the rest of the body exclusive of the wings.

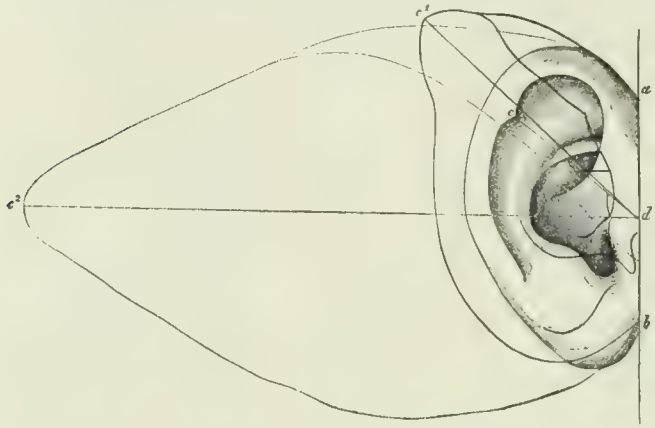


FIG. 1816.—The Human Auricle and Those of the Cynocephalus (a Species of Ape) and the Ox, so Arranged as to Show Their Relative Sizes and Shapes. (After Schwalbe.) *acb*, Auricle of the human being (drawn in detail); $ac^1b$, that of the ape (drawn simply in black outline); $ac^2b$, that of the ox (drawn in dotted outline); *dc*, $dc^1$, $dc^2$ represent the relative lengths of the three auricles.

To make a comparison between the auricles of man and those of animals it is necessary to have certain fixed points as a means for such comparison. For this purpose we take the true tip of the auricle (Fig. 1815, *c*) for one point, and the extremities of the base of the auricle, which corresponds to the front line of its insertion, for two other points (Fig. 1815, *a*, *b*). The triangle formed by joining these points (Fig. 1815, *a*, *c*, *b*) is designated by Schwalbe as the auricular triangle, and is the foundation for comparison between the auricles of all the mammalia. A straight line drawn from the true tip of the auricle (Fig. 1815, *c*) to the incisura auris anterior (Fig. 1815, *d*) strikes the basal line of the auricle close above the tragus; the distance between these two points being the true length of the auricle, while the distance between the two extremities of the basal line of the auricle is its true breadth. That this is the correct index for measurement is seen at once when the auricle of man is compared with that of the baboon and of the ox, by superimposing the outline drawings of the reduced auricles of these over that of the human auricle, in such a manner that the basal line or true breadth of the auricle of all three will be of the same size (Fig. 1816). The distance between the two points ($c^2$–*d*) is the true length of the auricle of the ox and is extraordinarily greater than that of the baboon ($c^1$–*d*), which is itself much larger than that of the human auricle (*c*–*d*). However, this noticeable reduction in length is not true of some other measurements. This can be demonstrated if the straight line (Fig. 1815, *a*–*i*–*k*) be drawn from the upper insertion point of the auricle to the sulcus auris posterior, at about a right angle to the line which represents the true length of the auricle. The first line divides the auricle into an upper or apical region, and a lower or basal region. The latter (Fig. 1815, *a*, *i*, *k*, *f*, *b*) is designated by Schwalbe as the region of eminences or the conservative portion, and the former (Fig. 1815, *a*, *i*, *k*, *c*, *e*) as the free auricular fold, or the variable portion. In the ape and especially in man the conservative portion is well marked, while in the majority of all other mammalia it is drawn into the funnel-shaped entrance of the external auditory canal.

It is in the apical portion of the auricle of man that the greatest change occurs. First, there is the marked involution of the free border of the ear in the formation of the helix. In animals only the beginning of the helix is involuted and the auricular tip occupies its highest point. In the higher order of apes the incurving of the helix is completed as far as the tip of the auricle, and in the genus *Cercopithicus* the auricular tip is moved down on the posterior auricular border (Fig. 1817, *a*), while in the chimpanzee (Fig. 1818) we find a beginning involution of this border. Second, the development of the crus superius anthelicis is connected with the progressive diminution of the human auricle, for if the human auricle is compared with that of the lemur, we find, in the latter, that of the entire antihelix system, only the crus anthelicis inferius (Fig. 1819, *b*) and the very lowest part of the antihelix (Fig. 1819, *c*) are developed. This last part is an extension of the antitragus, and these two crests are entirely disconnected. A third important point for comparison is the auricular lobe, which exists in man as a loose fleshy convex portion, pendant and free from cartilage. In a few apes the under border of the lobule is convex, but contains for the most part the broad cartilaginous continuation of the helix; only a small space beneath the incisura intertragica being free from cartilage. This is the first indication of the lobe, which exists only in man and the anthropoid apes.

*Variations* from the normal, as regards the dimensions, the form, or the inclination of the auricle, are sometimes observed.

Variations as to the dimensions of the auricle are to be considered from the individual standpoint as well as from a racial standpoint, and it is necessary to distinguish between the harmonious proportion which the width of the auricle bears to its length —*i.e.* between long ears and broad ears—as well as between large ears and small ears. The proportion which the height of the auricle bears to its width is the physiognomical auricular index, while the proportion between the true length of the auricle and the true width of the auricle is the morphological auricular index. The first may be expressed mathematically by the formula $\frac{\text{width} \times 100}{\text{height}}$ and the second by the formula $\frac{\text{base} \times 100}{\text{length}}$. The first is a true index for comparison between the auricles of different individuals and races, but is of no use, as was shown above, when the auricles of man is compared with that of animals. It is then necessary to employ the second formula.

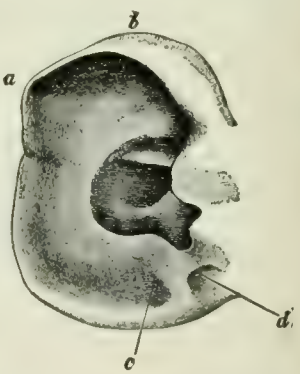


FIG. 1817.—Auricle of Cercopithecus Cynosurus. (After Schwalbe.) *a*, True auricular tip; *b*, highest point of auricle; *c*, lower end of the fossa navicularis; *d*, area lobularis; between *c* and *d* there is a rounded eminence which springs, on one side, from the cartilaginous cauda helicis and extends to the antitragus.

Among races the Mongolians have the smallest auricles, those of Europeans are larger, and the negroes have the largest auricles. As we descend to the anthropoid apes, the gorilla, the chimpanzee, and the orangoutang, and so on to the lower types of mammalia, we find the auricles continue to grow in size, that is, according to the physiognomical index; but when we measure these same auricles according to the morphological index, the reverse is found to be true, *i.e.* that man has the widest auricles in relation to their length.

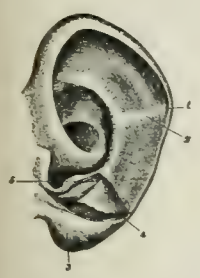

Fig. 1818.—Left Auricle of a Chimpanzee. (After Schwalbe.) In the vicinity of the antitragus and the cartilaginous cauda helicis the skin has been removed. At this point the cartilage of the antitragus, the musculus antitragicus, and the cauda helicis, can be seen. 1, Tubercle of Darwin's auricular tips: 2, crus anthelicis tertium; 3, lobule; 4, cauda helicis; 5, musculus antitragicus. (Reduced in size.)

*Variations in the Form of the Helix.*—These are the following: the failure of its posterior or even of its superior border to become inverted; the joining of the root of the helix with the antihelix; the division of the root of the helix into two or more branches.

*Variations in the Antihelix.*—Complete absence or greatly diminished size; an absence of its superior crus, or a doubling back of this crus and the consequent formation of an extra fossa.

*Variations in the Tragus and Antitragus.*—Attenuation or absence; division of antitragus into two tubercles.

*Variations in the Lobe.*—Very small size; adherence of its edge to the integument of the face; exaggerated vertical development; division into two parts, viz., an anterior and a posterior segment.

*Tubercle of Darwin.*—Of the many morphological anomalies, one of the most interesting is a projection, more or less marked, which appears on the free edge of the helix at the junction of its superior with its posterior border. It is sometimes found in the form of a simple tubercle or of a triangular plate. In the great majority of cases in which the helix is normally involuted, the Darwinian tip points downward and forward (Fig. 1820, A); but when the posterior border of the helix is not involuted in consequence of arrested development it points upward and backward (Fig. 1820, B), and the auricle terminates in a point as in animals. This last position indicates exactly its anatomical significance, but however it be placed, whether on a helix that is involuted or upon one that is not, it is always homologous with the ear tip of animals. It is always to be found in the human embryo before the sixth month, at which time the helix begins to roll in.

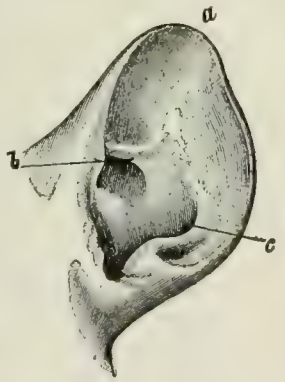

Fig. 1819.—Left Auricle of Lemur Macao. (After Schwalbe.) *a*, Apex of the auricle; *b*, crista anthelicis anterior (=crus inferius anthelicis); *c*, crista anthelicis inferior.

*Variations in the Inclination of the Auricles.*—These may be, as noted above, an abnormal slanting auricle or an auricle in which the cephaloauricular angle is over fifty degrees. All these variations from the normal are of interest to alienists and criminologists as they are to be found to a greater extent among the degenerate than among normally developed persons.

*Physiological Function of the Auricle.*—Darwin, Küpper, and others look upon the auricle as an appendage which has become useless in man. On the other hand, there are those who, like Gruber, believe that the auricle acts as a reflector and a conductor of sound waves toward the auditory canal. Weber believes it to be of service in locating the source of sound. Burnett considers that the auricle is a resonator; the region of the helix and its fossa resound to the deeper partial tones, the antihelix and its fossa to the intermediate partial tones, and the concha to the higher partial tones, and these tones are so blended by the auricle as to be received by the auditory nerve as a whole tone.

Robert Lewis.

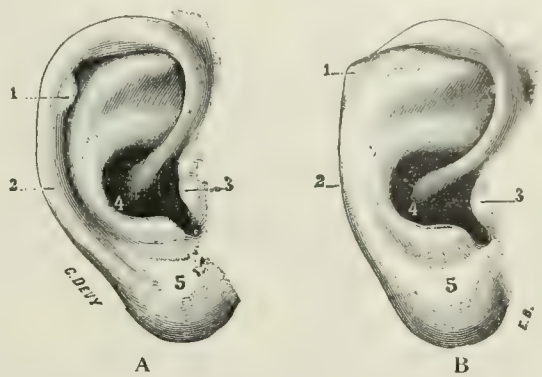

Fig. 1820.—Tubercle of Darwin: A, Looking Forward and Downward, upon a Normally Involuted Helix—the Most Common Type; B, Looking Backward and Upward upon a Helix Which is Imperfectly Involuted—Pointed Auricle. 1, Tubercle of Darwin; 2, posterior border of helix, normally involuted in A, not involuted in B; 3, tragus; 4, concha; 5, lobule. (After Testut.)

The information furnished in the present article has been drawn largely from the following sources:—

L. Testut: Traité d'Anatomie Humaine. Paris, 1897. Third edition.

Karl von Bardeleben: Handbuch der Anatomie des Menschen, Jena, 1897. Das Aeussere Ohr, von G. Schwalbe.

**Ear: Anatomy of the Mastoid.**—The mastoid portion of the temporal bone takes its name from the nipple-like process which develops upon its outer surface to form the major insertion of the sternocleidomastoid muscle, but it comprises all the part posterior to this which articulates with the occipital bone and forms a considerable element of the skull-base. Its demarcation from the petrous portion is indefinite and can be but arbitrarily stated by assigning to the latter all that encloses the labyrinth; but from the squamous portion it is easily separable at birth, and sometimes in later life, and its line of suture with the tympanic scroll is rarely effaced by growth. Its outer anterior part is largely ensheathed by these portions, and, paradoxical as it may sound, much of our "mastoid operation" is done upon this extension of the squama (Fig. 1821). Its surgical importance depends upon the liability of the tympanic structures within to incur septic infection, which is easily transmitted to it and to the more important adjacent structures, thus giving rise to a demand for intervention to eliminate such dangerous foci. Through the soft tissues, in life, little can be felt of the mastoid process except the convexity of the bony prominence, where the hairless skin and the periosteum form a thin covering, with only enough loose subcutaneous tissue to give free mobility to the skin (Fig 1822). Inflammatory induration and edema may distend this layer, however, to an inch or more in thickness, and so may render accurate palpation of the part impossible; but, so far as this difficulty is concerned, it is well to

remember that, much as the two sides may differ in other respects, there is apt to be enough symmetry to make the other mastoid a fair criterion for the size and form of its fellow.

Fig. 1821.—Inner Aspect of Squama in its Relation to the Annulus and Ossicles. The scute is partly hidden by the incus and malleus head, but the posterior and descending portions are well shown, with the tegmen roofing in both antrum and attic.

The mastoid process is a conoidal protuberance of the lower posterior portion of the temporal bone, and since it is in large part a response to the needs of the muscle inserted upon it, it shows an external form usually corresponding to the general osseous and

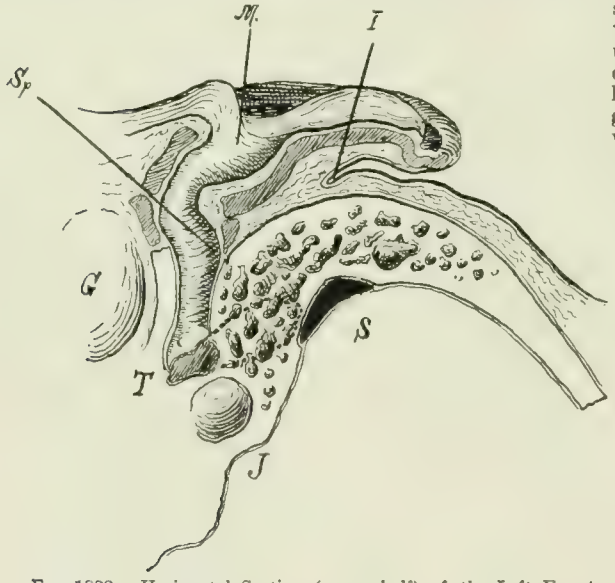


Fig. 1822.—Horizontal Section (upper half) of the Left Ear with the Soft Parts in Place, showing the location back of the meatus, *M*, and the spina, *Sp*, of the posterior insertion of the auricle, *I*. The glenoid cavity, *G*, the tympanum, *T*, and the jugular, *J*, are also shown; and the sigmoid sinus, *S*, which in this case is safely distant from the field of operation, is seen to be most superficial opposite the insertion of the auricle. A dotted line indicates the antrum.

muscular development of the individual; being large, rough, and massive in most strongly built males, and smaller, smoother, and thinner-walled in females and in males of slight physique. Its posterior boundary is partly marked by the deep groove of the digastric fossa, which intervenes between its apex and the skull-base; anteriorly, its convex external surface slopes inward to become the back wall of the meatus. Above, it may be said to extend to the curving and often ill-defined temporal ridge which extends back from the root of the zygoma; but it is better to con-

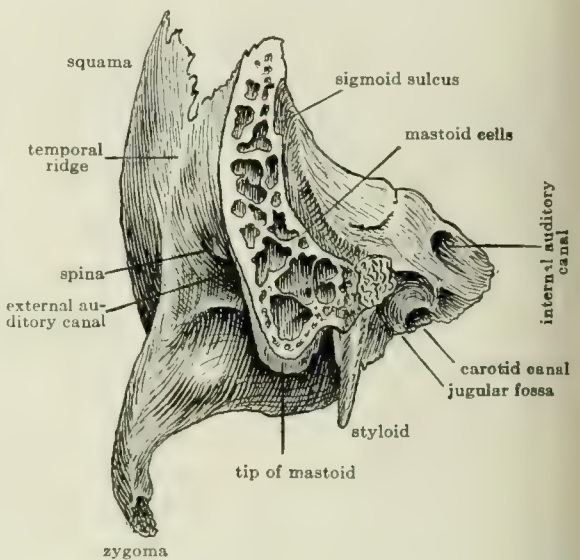


Fig. 1823.—Posterior Inferior Aspect of Temporal, sectioned nearly frontally to show the mastoid cells between the lateral sinus and the exterior, generally thin-walled toward the sigmoid sulcus and the digastric fossa within the mastoid tip.

sider it as ending at the imaginary horizontal line on the level of the upper edge of the zygoma and the upper margin of the meatus (Reid's base line). Almost exactly at the junction of these anterior and superior limits there may almost always be found a depressed groove or pit before which a spine or ridge projects toward the canal. This "suprameatal spine" (Fig.

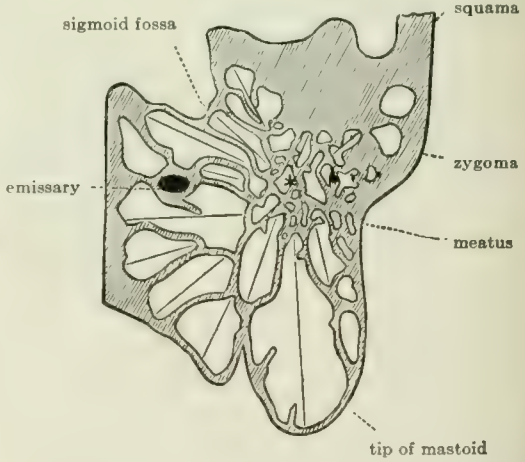


Fig. 1824.—Vertical Section of Mastoid Process at Right Angles to the Axis of the Auditory Canal, showing highly developed pneumatic cells and their radiating relation to the antrum*. (After Eyssell.)

1823), to which Henle and Bezold directed attention, is recognizable in the great majority of cases and forms a fixed and definite guiding-point not only for the mastoid but also for the whole skull. Kiesselbach found it in eighty-two per cent. of juvenile and eighty-seven per cent. of adult bones, and I have

rarely missed it among my specimens or in many hundred mastoids operated upon. Yearsley missed the spina in a considerable portion, but rarely the little pit behind it.

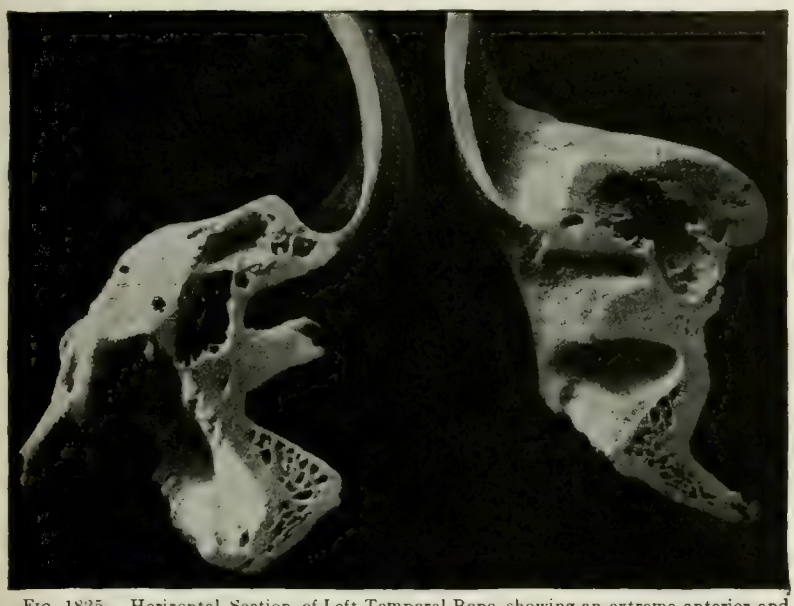

Fig. 1825.—Horizontal Section of Left Temporal Bone, showing an extreme anterior and superficial position of the sigmoid sulcus bringing the lateral sinus almost in contact with the meatus wall and the mastoid surface in the region of the spina, and rendering wholly impossible the ordinary operation for opening the antrum. (Randall, Photographic Illustrations.)

The mastoid process consists, externally, of a cortical lamina of compact bone, while in its interior it is more or less hollowed out by cavities, diploic or medullary in early life, but generally largely displaced, at a later period, by pneumatic extensions of the tympanum. As diverticula of the tympanic cavity these have a rather radiate arrangement in relation to it (Fig. 1824), and may extend not only throughout the mastoid but into all other portions of the temporal bone, to zygoma, sella turcica, carotid canal, and even inward or backward into the occipital. They may be said to be always most marked in the large mastoids, fewer and more imperfectly developed in the less prominent ones. Zuckerkandl's finding that among 250 bones 36.8 per cent. were wholly pneumatic, and 20.4 per cent. wholly diploic, while in 42.8 per cent. various combinations of pneumatic spaces and diploë existed, has not been borne out by the writer's study of 500 temporals, which showed a surgically notable proportion of diploë in hardly 10 per cent. of adult bones. Whether the diploic or the pneumatic structure is the more prone to septic infection and transmission does not appear. Cheatle claims that certain small cells external to the antrum are prenatal and constant and that the infantile type of otherwise noncellular outer wall persists in many adults, with an unfavorable tendency for any suppuration to become chronic. I hold with Buck and others that such a structure is often, if not usually, a pathological *eburnation*—the effect, not the cause, of chronic suppuration. The spaces are devoid of known function except as aiding nature's economy of material in developing the process in response to the needs of the muscle inserted upon it. Their practical importance is that they in a sense hold away from the cortex the inner table and the deeper structures which are related to it.

These inner structures—which are the ones that concern us from a surgical standpoint—are the lateral sinus, the dura and brain of the middle cerebral and the cerebellar fossa, and the facial nerve; and while modern writings might seem to indicate that we now operate more often with the purpose of reaching than of avoiding them, it will yet always be a piece of bungling needlessly or unintentionally to expose, still more to injure, any of them.

Fig. 1826.—Vertical Section at Right Angles to the Canal *M*, of a Diploic Right Temporal Bone, showing a forward and superficial position of the sigmoid fossa, *F*, and a middle cerebral fossa, *C*, lower than the temporal ridge. (After Hartmann.)

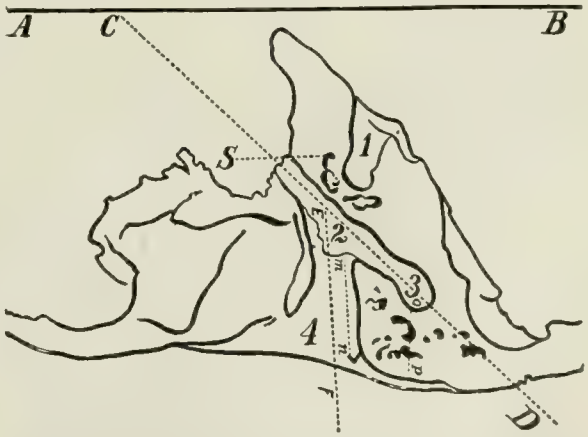


Fig. 1827.—Diagram of Right Temporal Bone Sectioned Horizontally and showing the Inclination of the Tubo-tympanic Axis, *C D*, to the sagittal plane *A B*; the length *m n*, of the upper back wall of the meatus, and the depth, *o p*, of the antrum from the operation point. 1, Meatus auditorius internus; 2, tympanic cavity; 3, mastoid antrum; 4, meatus auditorius externus. (After Allen.)

The lateral sinus occupies the sigmoid sulcus which grooves more or less deeply the inner posterior surface of the mastoid. The vessel itself is of very varying size, partly because the current of the longitudinal sinuses is rarely equally divided at the torcular—the main flow being oftener to the right; and the impress which it makes upon the bone is still more variable. In general, the larger the sinus is the more deeply do its curves hollow out the sulcus, pressing closer to the external auditory canal, to the mastoid cortex, or to both. The usual thickness of bone externally covering it averages seven millimeters (0 to 20), and this thinnest place is at a point averaging seventeen millimeters (0.5 to 40) back of the suprameatal spine. It approaches within twelve millimeters, on an average (0 to 25) of the external meatus, leaving a very moderate "operation space" through which the surgeon can penetrate to the antrum; but the minima stated show that there can be no *assurance* of safe penetration in this direction, since no rule can be laid down by which the less favorable relation can be foretold. In spite of some assertions to the contrary it has been proved that the dangerous relations (Fig. 1825) may be met in any type of skull and on either side. The only safe rule, therefore, is that of Hartmann, viz., to operate always as though the most dangerous relation were present until the contrary has been proved to be the fact. As regards its relations to the antrum, the sinus usually approaches it more nearly than it does either the outer surface of the mastoid or the external auditory canal, and the intervening bone is commonly occupied by cells. As a rule, therefore, the operator, in his work upon the mastoid, is brought into immediate touch with the thin wall of the sulcus—a structure brittle and easily penetrated even when healthy. A large emissary vein passes back from the lower curve of the sigmoid, channelling the bone to emerge at the back of the digastric

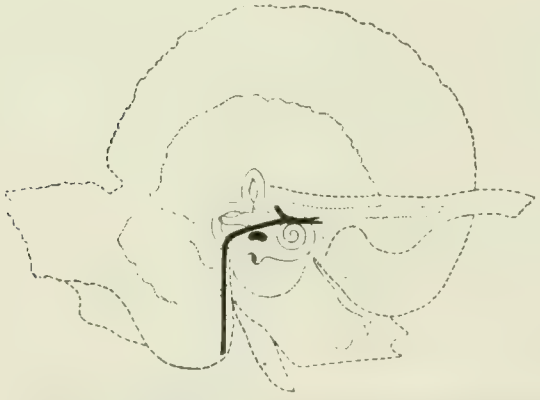

Fig. 1828.—The Facial Nerve in its Unchanging Relation to the Labyrinth in the Infant and in the Adult Temporal Bone.

fossa near the occipitotemporal suture. In rare cases, as in the fellow of the mastoid represented in Fig. 1825, the entire sigmoid sinus emerges here; and in other cases, although only supplementary, this emissary may be as large as a lead pencil.

The floor of the middle cerebral fossa has been said to correspond fairly with the ridge extending back from the zygoma above the meatus; but this suprameatal ridge is no safe guide, since the fossa not infrequently extends below it (Fig. 1826). The average height is six millimeters (0 to 18) above the *spina supra meatum* and the upper wall of the meatus, and this should form our landmark in entering the bone, as the fossa can never be below the meatus and is usually still higher back of it. An embryonic sinus not infrequently persists along the petrosquamous suture near the lowest part of the fossa. If the surface of the bone has been well bared, the surgeon will be able to distinguish the bluish tinge which is generally present when any sinus approaches very near to the external surface. The outer wall of the antrum is rarely less than fifteen millimeters from the surface (Fig. 1827.) Hence, in the adult, a penetration to a depth less than this will generally fail to enter the antrum. In the infant, however, the latter cavity is situated much nearer the surface. Nevertheless, one who has merely noted that it is just below the surface in the new-born will be surprised at the thickness of the bone which has to be traversed even in very young children before the antrum is opened.

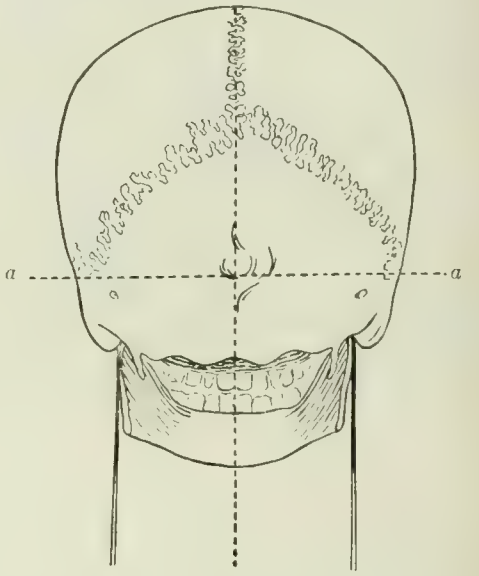


Fig. 1829.—Skull with Probes Impacted in Each Facial Canal, showing their vertical parallelism; *a a*, Reid's base line.

With them, fortunately, the separation of the sigmoid sulcus from the meatus is often actually, as well as relatively, greater than in adults, and, besides, this relationship is more constant. Mastoid operations should therefore be safer and easier in children.

The inner wall of the antrum is formed by the facial and semicircular canals (Fig. 1825); a fact which renders it dangerous, as regards the integrity of these important structures, unguardedly to enter this cavity to curette its walls, or even in some cases to pack the cavity. Measurements indicate that the facial canal is probably never less than twelve millimeters from the *spina*, although rarely more than twenty-five millimeters; and the latter distance should in doubtful cases be the limit of our penetration even in a large mastoid.

The problem of avoiding injury to the facial nerve grows more difficult in evisceration of the tympanic cavity in Stacke's operation or in the more radical tympanomastoid exenteration. In either case it must be remembered that the canal of the facial forms the upper lip of the fossa of the oval window, and curves thence backward and downward to a point situated from two to four millimeters back of the middle of the posterior margin of the tympanic ring. While the descending part of the canal is usually exactly vertical, it seems clinically to pass somewhat outward, because we refer its course to the annulus and forget how very oblique the position of this really is. Even the auditory canal generally points 5–10 degrees down and as much back as it passes outward, according to my measurements on 500 skulls. The descending course of

the facial is not often at right angles to the canal axis, therefore, but seems to tend outward, at times markedly; yet if we compare it with the horizontal or vertical plane, as we can in the macerated skull, we find it to vary little if at all from the exact vertical. If we remove the tympanic margin above, without striking across to the inner side of the drum cavity (Fig. 1827), and in removing the posterior margin keep above its middle, the facial and its canal ought to remain untouched. A spur of bone at the back wall of the canal—largely the back portion of the tympanic scroll—will thus be preserved, and beneath this spur will be the facial canal (Fig. 1830).

Fig. 1830.—Exenteration of Mastoid and Tympanic Cavities, showing prominence of facial canal above oval window, the sinus wall posteriorly, and the ridge covering the facial between.

It is well to note the relation of the soft parts to the underlying bony structures, as some errors in regard to this are prevalent. The incision preliminary to opening the mastoid has generally been made five or ten millimeters back of the apparent insertion of the auricle and parallel to its curve, and some of the older surgeons considered the boss of the mastoid, at or behind this insertion, as the proper point for entering the bone. At the present time the chosen point of entrance is well in advance of this, in the region covered by the concha (Fig. 1822). The finger thrust into the meatus and pressed upward and backward can generally feel the spina, and it is at a point close behind this that the chiselling usually begins. The insertion line of the auricle, back of the meatus, corresponds to the average position of the sigmoid sulcus at its most superficial and anterior position, *i.e.* about fifteen millimeters back of the spina.

B. Alexander Randall.

**Ear: Anatomy of the Tympanic Membrane and Ossicles.**—Otoscopic examination shows the auditory canal to have a depth of about thirty millimeters, ending in a grayish membrane, the drumhead. This delicate septum is of irregular oval form, some ten by nine millimeters in size and very obliquely set—although the extreme inclination is not very apparent except when the membrane is unduly opaque. It is very usual, therefore, to regard its inclination as differing at different ages and in different individuals; although in fact it is almost solely a variation in the axial direction of the canal which is observed. This axis is in some persons almost transverse, even the cartilaginous portion needing little of the usual traction up and back to afford a good view of the fundus. In others, as we easily determine by reference to the plane of the eyebrows, the canal points far forward and upward as it passes inward, with notable effect upon the appearance of the drumhead. Even narrowness of the canal, by rendering examination less easy, makes the obliquity of the drumhead more evident; and this is especially true in the young child in whom the narrow flaccid canal must be drawn *down* in order to straighten it. As much from this as from the striking approach to the horizontal which is seen in the tympanic membrane on the base of the prepared skull of the infant (but is as evident in the drumhead of the adult when equally exposed), has arisen the erroneous tradition that the plane of the drumhead grows less horizontal with age. No change so far as is known occurs in the size or inclination of the drumhead after birth. The growth of the skull-base pushes the drumheads apart, doubling the distance between them; a like growth of the bony external meatus changes the size

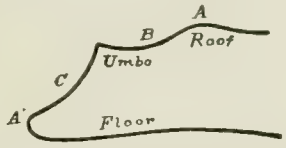


Fig. 1831.—Contour of Drumhead and Canal-walls in Vertical Section. A horizontal section would give a closely similar configuration.

and direction of this canal and may seem to reveal a difference in the depth and slope of the tympanic membrane, but careful measurement shows no substantiation of such a view. The front margin of the drumhead is some six millimeters farther from the tragus than the posterior; the lower margin six millimeters farther than the upper; and even these total distances are almost identical in child and adult, for a membranous canal represents in infancy the portion which is later to be bony.

Drum-membrane.—The first point to catch the eye in study of the normal drumhead is the bright reflection of light at its lower forward part—almost as bright as that from the cornea, but a dry luster of the smooth epiderm as from a polished finger-nail. It is triangular or cusp-shaped, extending from its base at the periphery to its apex near the center of the tympanic membrane, like the silvery head of an arrow pointing from the chin—the miscalled "pyramid" or "cone of light." Its apex marks the depressed center or "umbo" of the drumhead; and from this point extends upward and forward an opaque whitish ridge, the "manubrium" or handle of the malleus, apparently prominent especially as it approaches the upper margin. Here a pearly nodule is formed by the "short process" of the malleus pushing outward the membrane, which falls away in variably marked "anterior and posterior folds," which seem thicker than the membrane below and often merge into a marginal whitish thickening of the drumhead, the annulus cartilagineus or tendinosus, which forms its insertion into the sulcus of the tympanic ring. Beyond this the canal wall, opaque and flesh-colored, strongly contrasts as a rule with the more or less transparent membrana tympani.

Fig. 1832.—The Normal Membrana Tympani.

Above the short process the margin usually shows a considerable notch, an arc of shorter radius than the rest, marked front and back by the extremities of the horse-shoe of the incomplete tympanic "annulus,"

varying as the squamosal margin more or less completely rounds out the gap between the "cornua" of the tympanic ring. This "Rivinian notch" shows none of the peripheral thickening of the cartilaginous annulus, and the portion of drumhead which fills it is less sense than the remainder—hence Shrapnell called it the "flaccid membrane" and it is often given his name. It varies much in size and appearance; but it is always worthy of scrupulous study, since its inner relations differ from the rest of the drumhead and it is more easily depressed and perhaps distended than the lower "membrana tensa." It often shows a dark point at or near its uppermost margin, the so-called "foramen of Rivinus" which was pointed out by Riolanus and Rivinus, but especially by Bochdaleck as a normal opening. Present in twenty-five per cent. of adult drumheads, often with no history of even an earache, it is none the less of pathological significance—the perforation or scar resulting from the outbreak at this point of discharge, often only a drop or two, which failed to show externally. It is usually at the very upper-front margin and of distinct funnel-form, moving in response to the pneumatic speculum; but it is at times central in the flaccid membrane or in its posterior part. No developmental reason can be given for its presence, it is absent in the embryo and infant, rare in early life and I have never found it in more than ten per cent. before puberty, although seen in one-fourth of all adults; the burden of proof that it is not pathological rests on those who would maintain such a view.

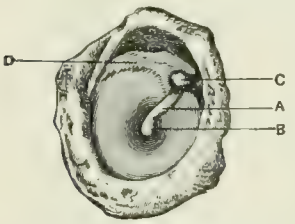


Fig. 1833.—View of Outer Surface of Membrana Tympani. (Gruber.) *A*, malleus, manubrium; *B*, lower end of manubrium; *C*, short process; *D*, posterior fold of the membrana.

The color of the drumhead depends greatly upon the inner structures seen through it and some description of these is essential to our present study (see Plate XXXII). The tympanic membrane is itself slightly more opaque near the tip of the manubrium because of concentrated fibers and cells said to be cartilaginous. The nearly central umbo, depressed some two millimeters deeper than the plane of the margin, is within some two millimeters of the "promontory" or convexity of the inner wall due to the first part of the cochleal tube—this shows its yellowish color just down and back from the center. A little back of this the round-window niche gives a dark hollow, which can generally be recognized near the lower posterior margin. Below this a bluish coloration may mark dehiscence of the tympanic floor through which the jugular bulb is faintly visible (very rarely through an inflamed drumhead), ready to bleed seriously if opened by incision of the membrane. Only four or five such accidents have been reported: but it is doubtful if every one who has suffered it has recognized it or has rushed into print to proclaim it. Forward above the light-spot an ill-defined shadow indicates that the tympanic mouth of the Eustachian tube has a funnel-like depth; and above it near the short process a shadow may sometimes be seen below the semi-tube of the tensor tympani. Up and back the falciform fold which forms the posterior pouch of v. Troeltsch can usually be seen, its posterior lower edge carrying the "chorda tympani nerve" like the "bolt-rope" of a sail; and its anterior edge, fibrously thickened, curving down for attachment along the malleus-handle. Protruding from beneath this fold the shank of the incus (long descending process) extends parallel to the manubrium, generally showing a slight backward curve because we see behind it into its mesial bend. Back from near its tip a nearly horizontal light band marks the stapedius-tendon passing from its insertion toward the apex of its containing pyramid. The stapes is never seen under normal conditions—its head and anterior crus are hidden by the incus-shank; the deep and shaded posterior crus, by this thread of overlying tendon. It is here worthy of note how greatly a whitish flake or thread in the otoscopic view interferes with any objects lying beyond it, seeming to hold the eye and cast into deeper shadow all that lies farther in, even though really visible. Bearing in mind these deeper structures which are more or less discernible through the drumhead, each lending its color to the overlying membrane, it is evident that the bluish-gray or pearl-color is very variously modified. Indeed it is somewhat of a question if we clinicians really know the normal appearances. Once at least I have seen in a normal ear a drum-membrane so transparent that it appeared as a mere sheen in front of the deeper structures, as if a microscopic cover-glass or a bubble-film were across the canal. Any opacity or color of the drum-head ought perhaps to be regarded as abnormal. Yet the membrane has decided strength; for while I have not gotten it to withstand more than thirty inches of mercury or a pressure of fifteen pounds to the square inch, others have obtained results even the double of this.

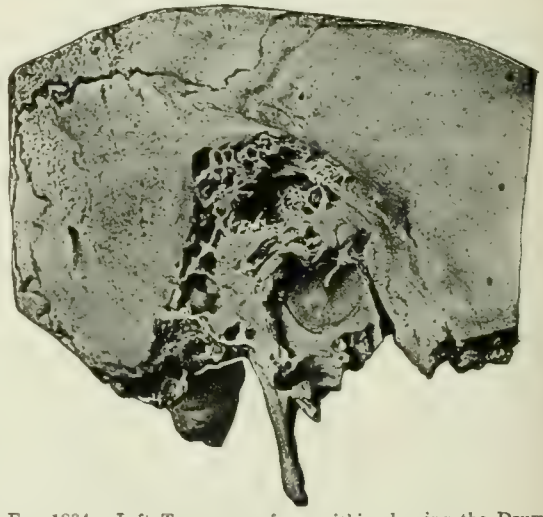

Fig. 1834.—Left Tympanum from within showing the Drumhead, Ossicles, Chorda Tympani and the Three-fold Conformation of Antrum, Attic and Atrium or Drum Cavity Proper. From a preparation of C. J. Blake (Randall & Morse, Photographic Illustrations.)

The area of the drumhead is about seventy square millimeters, divided naturally by the malleus-handle somewhat unequally, as the posterior portion is generally the larger. These halves are usually further divided into quadrants for convenience of description, but the lines are variously laid. Schwalbe assigns sixteen square millimeters to the upper anterior, six to lower anterior, fourteen to lower posterior and twenty-seven to upper posterior, with six to the region of the manubrium. A better and more uniform division would seem to be into halves by the manubrium and its extension to the lower margin and halving these by the diameter at right angles to this. The membrana tympani or drumhead consists of three layers because it is formed by the invagination of the ectoderm to form the external auditory canal, the outgrowth of the endoderm from the pharynx and first branchial cleft to form the Eustachian tube, tympanum and pneumatic cells of

the temporal bone, while between these grows a partition of mesoblast, which differentiates into fibrous, cartilaginous, and bony tissues. It presents, therefore, externally a thin dermal layer continuous with that lining the external canal, internally a mucous membrane continuous with that of the nasopharynx, and an intermediate fibrous membrana propria in intimate relation with the bony hammer-handle.

The dermal layer, which in the deeper portion of the canal has lost its hairs, sebaceous glands, and the coiled sweat-glands (which in the ear secrete the cerumen), is still more delicate as it passes across the drumhead, losing its papillæ at the margin and presenting only several layers of epidermal cells and a thin layer of subcutaneous areolar tissue in which course the blood-vessels and nerves. Both layers

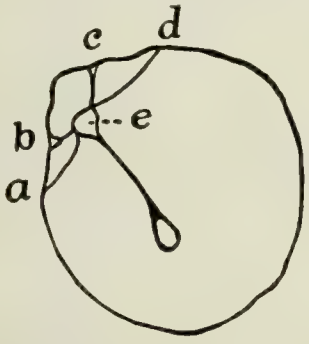


Fig. 1835.—Diagram of Drumhead showing at *e* the short process with the anterior fold running from *d* to *a*, the posterior fold to *d*, and the suspensory folds to *b* and *c*. The hammer-handle descends in narrow contact with the drum membrane to about its center where it is fully imbedded.

are thicker near the upper pole of the drumhead, where the main vascular and nerve supply passes upon the membrane and lies along the back border of the hammer-handle as the manubrial plexus. In this band glandular structures are sometimes found. The epiderm of the drumhead is one of the most rapidly proliferating in the body, especially near its center. It tends to spread from the center to the periphery almost as a syrupy fluid spreads when poured, pushing the older cells before it to the margin and out upon the canal-wall. These have migrated from the surface of the normal drumhead, therefore, before they exfoliate and they even carry with them any adherent foreign material—as when to study this movement, Blake glued scraps of paper to various parts of the surface, finding the most rapid progress up and back.

The mucosa of the drumhead, continuous with the mucous membrane of the middle ear and pharynx, consists of a single layer of cuboid epithelium, nonciliated unless at the margins and supported on a very delicate submucous layer with a blood-vessel network and a nerve-supply generally described as scanty. Like the mucous lining of other accessory cavities of the upper air-passages it can undergo very rapid edematous and hyperplastic thickening. A few villous growths are sometimes found in normal cases.

Between the dermal and mucous lamellæ stretches the "membrana propria" of the drumhead constituting most of its 0.1 millimeter of average thickness. This consists mainly of an external layer of radiate, and a mesial layer of concentric circular fibers. The latter can hardly be separated from the mucosa; but the cutaneous covering can be readily detached from the exterior and the fibrous laminæ dissected apart. They can thus be seen to consist of rather stiff, inelastic ribbon-like fibers, rarely branching, with elongated nuclei occasionally interposed. They arise largely from the peripheral *annulus tendinosus* but some of them in the substance of the lamma, and are most of them inserted upon the handle of the malleus. Those of the radiate layer converge throughout the lower half of the drumhead toward the tip of the manubrium at the umbo, their massing increasing the thickness of this layer from 36 $\mu$ peripherally to 84 $\mu$ near the center. In the upper half their direction is rather less converging and they spread along the length of the hammer-handle. The circular fibers are most numerous near the periphery, where they constitute the main thickness of the drumhead, and grow fewer as we approach the center. They too are attached along the manubrium. Gruber has described a sheath, largely cartilaginous, enveloping the hammer-handle and short process, but more or less separated from it by synovial spaces and receiving the insertion of all of these fibers. Few other students accord this so definite an entity. A lamina of cartilage can generally be distinguished between the bony handle and its periosteum; but it does not seem quite continuous, it dips at times deeply into the bony structure and the true relation of many of the fibers is that they pass external to the manubrium and loop around it. At the umbo they pass generally internal to it, leaving its flattened facet slightly covered.

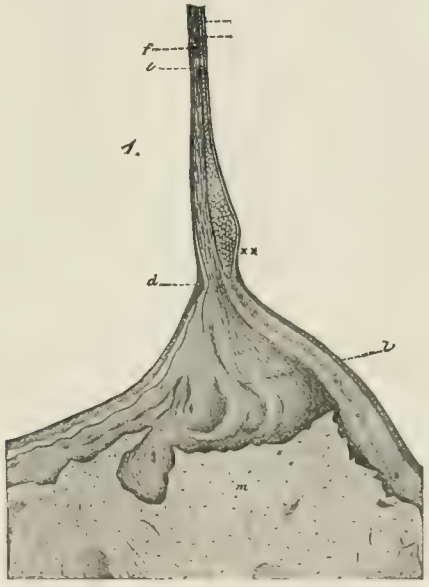


Fig. 1836.—Vertical Section of Lower Part of Drumhead. × 35. (Brunner.) On the left the skin of the canal thins as it passes over the tendinous annulus (*l*), until at *d* it is hardly more than epiderm (*e*); so too does the tympanic mucous membrane on the right (*h*). The membrana propria shows its radiate fibers (*f*) passing into the thickened fibrous annulus for insertion into the bony groove (*m*); while the transversely cut circular fibers, sparse at *g*, thicken at the margin into a firm ring (*xx*).

Partial layers of arborescent or reticular fibrous tissue and a set of descending fibers have been described, as also a series of stellate or spindle-cells comparable to the corneal corpuscles; but these are largely associated with the networks of blood- and lymph-vessels. The main blood-supply of the drumhead comes from the deep auricular artery, and an arterial twig with accompanying veins passes along the back margin of the hammer-handle, sending radiating branches out to the periphery, where there is free inosculation with finer vessels from the cutis of the walls. A fine-meshed capillary net covers the whole area, the engorgement of which gives a vivid general redness to the inflamed drumhead, concealing the individual twigs previously conspicuous and soon itself

lost to sight behind the macerated epiderm. A similar vascularization of the mucosa is derived rather directly from the carotid and has numerous anastomoses, especially near the periphery, with the cutaneous supply. The efferent veins pass principally out along the front wall of the meatus, where they are easily compressed by careless use of a speculum, with quick engorgement of the normal drumhead. This also explains the good derivative effect of leeching at the tragus in middle-ear inflammations.

Fine nerve-filaments accompany the blood-vessels, with very variously described distribution to its structures. They render the normal drumhead very sensitive, especially as its upper anterior part; but some of its sensibility is really acoustic—a hearing rather than a feeling of any contact with the surface of the drumhead. It is lessened, therefore, in nerve-deafness; just as stroking of the tragus in such a case gives an impression of numbness because not heard as well as felt. The partial anesthesia of the drumhead in many cases of facial palsy is less certainly explicable.

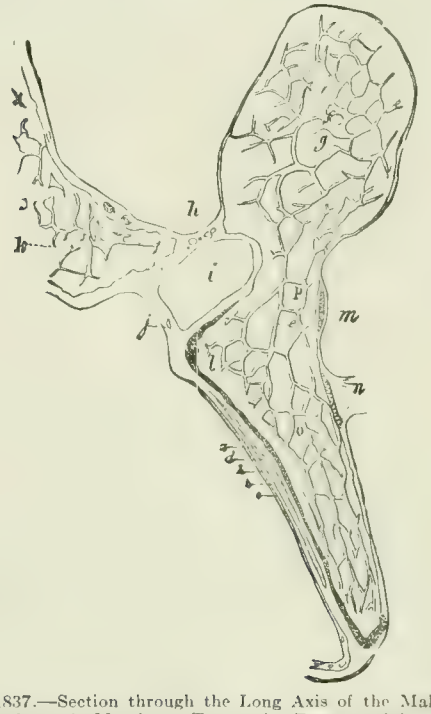


Fig. 1837.—Section through the Long Axis of the Malleus at Right Angles to the Membrana Tympani. From an adult. (Brunner.) Bony edge of the so-called scute or inner edge of upper wall of auditory canal, in the segment of Rivinus; *g*, head of the malleus; *p*, neck of the malleus; *o*, handle of the malleus; *l*, short process of same; *j*, membrana flaccida; *h*, ligamentum mallei externum; *m*, chorda tympani; *n*, tendon of tensor tympani; *i*, a cavity, according to Prussak and others; *a*, cartilage; *b*, *b*, fibers of the membrana tympani; *c*, dermoid layer of the membrana tympani; *e*, Haversian canals; *f*, medullary space.

While it is very evident that much of the funnel-shape of the drumhead is due to its attachment to the hammer-handle and that the tensor tympani muscle acting upon this must draw the membrane more inward, the outwardly convex curve of the radiate fibers of the *lamina propria* demands some other explanation, as such traction would tend to bring them into straight lines. The hammer-handle has slight outward curvature and the drumhead attached to it must correspond closely to its curve—but this is perhaps the flattest part of the drumhead. Further we find that the membrane cut loose from its peripheral attachment becomes still more funnel-shaped. This is generally ascribed to the influence of the circular fibers, as they seem to offer the only plausible means of thus counteracting the stiffness and tension of the radiate fibers, in spite of the statement of Toynbee that if the two lamellæ be separated, it is that of the radiate fibers which assumes the more acuminated form.

This peculiar form has its physiological importance and deserves full consideration because Helmholtz tells us that a membrane of such contour is capable of responding to the most various of sound-waves with equal readiness and has hardly a fundamental of its own to which it would be preponderatingly consonant.

Where the drumhead meets the bony walls we can usually see at more or less of its circumference a whiter zone—the "tendinous annulus." This shows in section as a wedge-shaped thickening of fibrous aspect which fits the groove of the tympanic ring as the margin of a watch-crystal is set into the ring which holds it. The periosteum of the groove and of the adjacent bone can be in some measure differentiated, but virtually is continuous with this "ring-wulst" of Gerlach. Since Arnold showed that it was mainly composed of wavy fibrils, students have been wary of admitting the presence of cartilage-cells which gave it its older name of "annulus cartilagineus"; but the round cells sparsely present can hardly be other than cartilage-cells.

The Auditory Ossicles.—A chain of three tiny bones is present in the tympanic cavity of mammals, connecting the drumhead with the recipient apparatus in the labyrinth. The outermost, the "malleus" or hammer, has its handle united throughout its length with the tympanic membrane; the innermost, the "stapes" or stirrup, closes with its foot-plate the oval window; while between them the "incus" or anvil articulates with each to form the

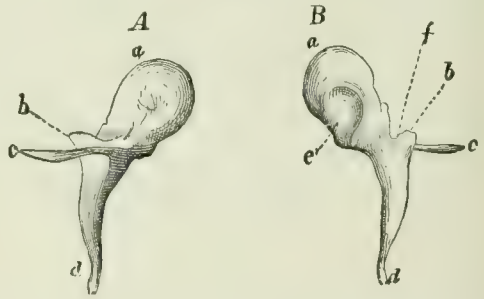


Fig. 1838.—Malleus of the Right Side. *A*, From in front; *B*, from behind. (Magnified four diameters. Henle.) *a*, Head; *b*, short process; *c*, long process; *d*, manubrium; *e*, articular surface for the incus; *f*, the neck.

connecting link. Their development is not surely known, but the two larger seem to arise as segments of Meckel's cartilage, while the stapes develops from the second arch. Its foot-plate has been claimed as belonging, in origin, to the labyrinth-capsule.

*The Malleus* is rather club-shaped and consists of a pear-shaped head, a neck and three processes, of which the manubrium or handle constitutes one-half of its eight to nine millimeters length but hardly one-fifth of its seventeen to twenty-four milligrams weight. The rounded head is united to the handle at an angle of 135°; so its resemblance to a machinist's hammer is not wholly fanciful. On the posterior aspect of the head, beginning near its top and winding spirally in and down, is a depressed articular surface with prominent margins, having a twisted saddle-shape, for union with the incus. On the lateral surface a spiral ridge, the sigmoid crest, parallels this but is mainly on the neck and furnishes attachment for the external ligament of the malleus. The constricted neck, deeply notched just below this ridge,

expands abruptly into the short process, a strong conical projection which presses outward the drumhead at this point and forms one of the most important landmarks of the clinical picture. Below the short process the bone tapers as the manubrium or handle, rather flattened on the anterior and posterior aspects which meet in the nearly straight exterior ridge which is in contact with the tympanic membrane. Near its distal extremity the handle curves forward, sometimes strongly, and has a flattened facet on its outer aspect, giving it a somewhat "gum-lancet" form. Forward from the neck extends the third or "gracilis process," a curved scythe-blade some five millimeters in length in the infant and deserving its name of "long process." It enters the glenoid or Gasserian fissure and is firmly attached to a conforming ridge on its outer wall, at first by fibrous union but is later usually co-ossified and breaks off from the malleus when this is removed. Sometimes it may absorb, as is claimed to be the rule. In the adult, therefore, the truncated base one or two millimeters long alone remains; but exceptionally it is removed intact. Mesially, near the origin of the gracilis process, a faint tubercle is sometimes present for the insertion of the tensor tympani.

Fig. 1839.—Horizontal Section of Malleo-incudal Joint, showing synovial sac and intra-articular meniscus also the suspensory ligament of the malleus and the fan-shaped attachment of the incus posteriorly to the tympanic wall. (From a preparation by Dr. Ralph Butler.)

*The Incus*, so-called because its upper part has somewhat the shape of an anvil, is perhaps better likened to a molar tooth with two widely diverging fangs. Its body has on its anterior aspect an articular surface corresponding to that of the malleus, with which it is in contact. This is marked by an upper outer and a lower inner projection or "cog," overlapping the conforming depression of the malleus. These give to the joint much of the ratchet-arrangement with which we are familiar in the stem-winding watch—the cogs catch as the malleus-handle moves inward, but release their hold as it moves outward. Together the two ossicles form a compound lever, but its action is mainly in response to the depressions of the drumhead—when the membrane moving outward carries the manubrium with it, little outward traction is exerted upon the incus and through it upon the stapes. Backward the body of the incus contracts into a conical horizontal or short process, which is fastened to the posterior tympanic wall just below the opening of the antrum. A flattened surface is often found here on the inner, less often on the outer, aspect, and in rare instances this is a distinct articular facet, which forms with the wall a true incudotympanic joint. This surface, if not the whole tip, is usually covered with hyaline cartilage. Even in the ligamentous union I have seen a synovial or bursal sac and in one instance a sesamoid bone. The long, descending process or shank of the incus passes with slight sigmoid curve down about parallel to the malleus-handle, then turns at a right angle inward and expands into the lenticular process, a button-like plate of bone for articulation with the dished head of the stapes. In the embryo, as in some animals throughout life, this is a separate *os orbiculare* (*Sylvii*), but in extrauterine life this is united by a delicate, vertically compressed, neck to the incus, from which it is easily broken away. The lower edge of the short process is sometimes deeply notched,

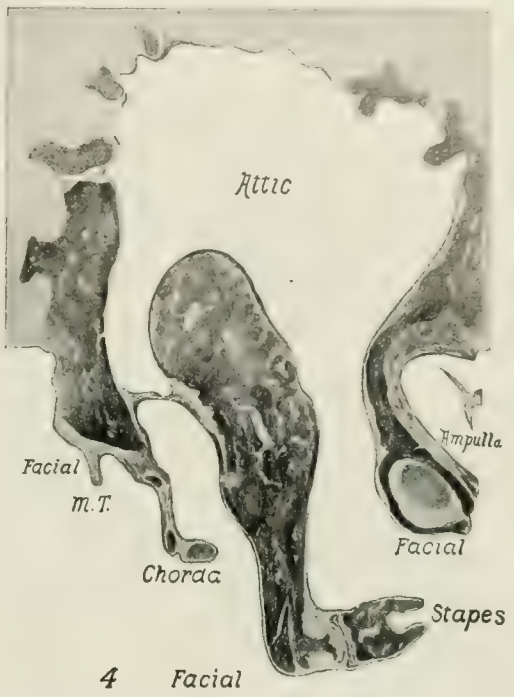


Fig. 1840.—Vertical Section through Tympanum and Incus, showing the synovial sac and intra-articular meniscus between the lenticular process of the incus and the stapes-head. (From a preparation by Dr. Ralph Butler.)

forming an entrance point for nutrient vessels. The vascularization comes largely from its attachments to the tympanic wall and to the malleus, as also through any adventitious folds which connect the incus to the walls; but it is more easily impaired than that of the other two ossicles, so the incus shows decidedly greater tendency to caries, most especially

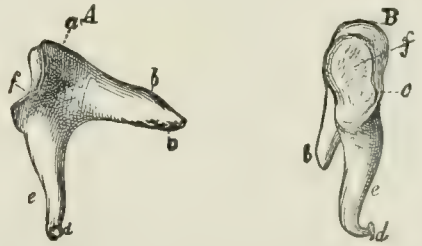


Fig. 1841.—Right Incus. (Magnified four diameters. Henle.) *A*, Inner surface; *B*, view in front; *Aa*, and *B*, body; *b*, short process; *e*, long process; *d*, processus lenticularis; *f*, articular surface for the head of the malleus; *c*, surface which lies in contact with wall of tympanic cavity.

of its descending process, and is the most likely to be exfoliated.

*The Stapes*, an exquisite miniature stirrup as its name implies, is the tiniest bone of the body, little more than three millimeters in length and weighing some four milligrams. Its foot-plate, slightly convex mesially, has the reniform outline of the oval window

into which it fits—its upper margin convex, its lower straight or slightly concave. It is very thin in the center, as its tympanic surface is hollowed out; but its margins thicken notably, furnishing quite an articular surface all around for relation to the window-margin. From near the front and back edges of the foot-plate rise the arching "crura," strongly grooved on their concave aspect, to meet some three millimeters from the basis and support the tiny head, which rarely shows any constricted neck at its junction with the arch—oftener it has a vague tubercle backward for the insertion of the stapedius tendon. The posterior crus is generally the longer and more curved, but the plane of the slightly concave head rarely differs much from parallelism with the foot-plate. Between the crura an obturator membrane or network of fibers is often found.

The articular margins of the foot-plate, like those of the oval window, are sheathed with hyaline cartilage and a layer of fibrocartilage, widest anteriorly, unites the opposed surfaces. Internally passes the periosteum of the interior of the labyrinth-wall to cover the inner aspect of the stapes, while the delicate muco-periosteum of the tympanum clothes the outer surface of the foot-plate as well as all other parts of the ossicles. Both of these are rather lightly attached and interfere little with the play of the stapes—indeed the stapes can sometimes be extracted without rupture of this periosteal membrane closing the window. Most anatomists describe the stapedio-fenestral articulation as a synchondrosis; but Butler and I have often found at the back margin a distinct synovial cleft in the fibrocartilage. No other part of the "annular ligament" has showed such cleavage, its form when present is fairly constantly wedge-shaped with base inward, and its cavity when stretched widely is spanned by a few fibrils of such delicacy as must certainly have been ruptured had the cleft been an artifact.

The round tendon of the stapedius emerges from the pin-hole at the apex of the pyramid on the back wall of the tympanum and is inserted on the head of

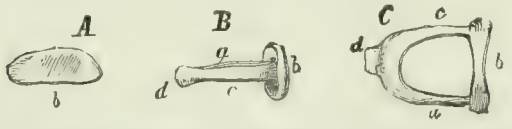


Fig. 1842.—Right Stapes. Magnified four diameters. (Henle.) *A*, From within; *B*, from in front; *C*, from beneath; *b*, foot plate or base; *d*, capitulum; *c*, anterior; *a*, posterior shaft or crus of stapes.

the stapes and the adjacent capsular ligament. It is sometimes accompanied by folds of mucous membrane or fibrous bands, which unite the crura of the ossicle to the walls of the niche about it, but need not impair its due mobility, since they have been marked in cases known to have had good hearing. Yet it must require little thickening and stiffening of these by morbid processes to cause pseudoankylosis.

The articulations of the incus with the other two ossicles are true joints, although much disputation has raged about this matter. With the stapes it articulates by means of the lenticular process, which is as slightly convex as the head of the stapes is concave. Each surface has the usual sheathing of hyaline cartilage and is bound to the other by a firm capsular ligament, reinforced by fibers of the stapedius tendon. Between the opposed faces a synovial sac is generally sharply defined, often as a forked cleft by reason of its passing to both sides of a wedge of intraarticular fibrocartilage. This unites with the posterior capsule as a rule, but also shows variable adhesions to the articular surfaces, giving in such sections no visible joint cavity at that point. If such adhesions come opposite to each other, the sections will give the appearance of a synchondrosis, although the next serial section may show the synovial sac unmistakable. The same is true of the larger articulation of the malleus and incus. Here a strong mesial ligament strengthens the capsule, and in most sections a notable meniscus of intracapsular fibrocartilage has its wedge-base in contact or union with the mesial ligament, but is separated more or less sharply by joint-cavity from most of each articular surface. Here too we may get sections which may be compared with those of the knee-joint passing through the crossed ligaments and semilunar cartilage or the ligamentum teres of the hip-joint, and revealing little if any synovial sac. This explains why good anatomists have been so contradictory in their

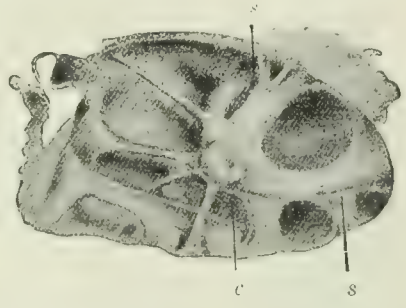


Fig. 1843.—Stapes and Niche of Oval Window, from a Normal hearing Adult, showing bands from the walls to the crura. (Politzer.)

descriptions—each has chosen a few sections as typical and has ignored the others of his own as well as of colleagues.

Ligaments bind the ossicular chain in position and furnish the pivotal points upon which the compound lever of malleus and incus swings. Posteriorly a fan-shaped fibrous band, often cleft into a mesial and an external, fastens the horizontal process of the incus into a niche of the back wall of the tympanum at or below the floor of the "aditus ad antrum." Hyaline cartilage often sheathes the inner or all sides of the tip, as also less frequently the related sides of the niche; rarely a true articulation with vague synovial sac can be seen here. When the union is only ligamentous and mainly to one side, I have yet seen a bursal or synovial sac intervene between the incudal cartilage and the fibers passing transversely to it, and in one instance inclosing a sesamoid bony nodule.

Above the head of the malleus a suspensory ligament attaches it to the tegmen—sometimes round and thread-like—usually falciform with the more mucous folds which supplement it, so that it may extend from the Glaserian fissure up over the head of the malleus and back along the body of the incus. Butler has described a jutting tubercle of bone on the anterior wall of the tympanum forming a true joint with a small area of the front of the malleus-head. This finding seems anomalous and unique. Usually the anterior pivotal point is furnished by the gracilis process and the accompanying anterior ligament, which with the chorda tympani and various adventitious folds pass to the Glaserian fissure. Laterally there is a strong band of the external ligament arising from the outer attic-wall between the cornua of the annulus and converging for insertion upon the sigmoid crest, the spiral ridge on the neck of the malleus. Sometimes it is inserted more widely and passes back upon the outer aspect of the incus. Between this and the flaccid membrane is Prussak's pouch, sometimes limited by the neck and short process of the malleus—again more extensive and in relation to the body of the incus (Kretschmann). Other folds, generally only duplicatures of the mucous membrane, may variously divide

the spaces of the attic and to a less degree the lower tympanum; but they hardly affect the motion of the ossicles unless pathologically thickened. If the gracilis process be fully present but ankylosed to the wall against which it lies, its delicacy but makes it a spring, defining the normal position of the malleus rather than impeding its minute movements. Each inward excursion of the drumhead carries the hammer-handle more or less with it, as is easily seen with the pneumatic speculum: this causes a like inward swing of the incus-shank, smaller but with increased force, which presses the stapes piston-like into the labyrinthine vestibule. Manometric studies show the action of these impulses upon the perilymph, whence they are passed, by a mechanism that is in dispute, to the acoustic nerve-endings. The finer vibrations of the high-pitched tones probably pass rather by molecular conduction through the ossicles or, evading them entirely, cross the air-space of the tympanum to act directly upon the labyrinth-windows, unaided but little impeded by the ossicular chain or the drumhead itself.

Special names have been given to portions of the ligaments of the ossicles as set forth in Fig. 1845: like everything upon which Helmholtz has set his seal, these deserve careful consideration if not full acceptance. Numerous variable or inconstant folds of mucous membrane constitute additional attachments of the ossicles to each other or to their surroundings, but seem of minor importance.

Fig. 1844.—Diagrammatic Representation of the Relation of the Ossicles to One Another, to the Membrana Tympani, and to the Internal Ear. (Buck.) *T*, Cavity of tympanum; *L*, labyrinth; *M.A.E.*, meatus auditorius externus; *H*, hammer; *A*, anvil; *S*, stirrup; *M.T.*, membrana tympani; *F.R.*, fenestra rotunda.

The tensor tympani muscle, occupying a semi-tube in the upper part of the bony passage for the Eustachian tube, arises in part from its "hook-cartilage" as well as from the walls about it (some of its fibers may be continuous with those of the tensor veli palati—Weber-Liel) and sends its tendon through a pulley overlying the apex of the cochlea and just in front of the oval window, to cross the tympanic cavity for insertion upon the handle of the malleus. Here a tiny tubercle or ridge is often present or at least a thicker plate of cartilage to mark its insertion. Although attached some two millimeters below the pivotal line of the malleus, this point is four millimeters above its tip and the muscle can act effectively to draw inward the drumhead or increase its tension. As it is inserted somewhat on the front aspect of the manubrium it tends to rotate it, deepening the anterior portion of the membrane. This may furnish a distinction between a "depressed" and a "retracted" drumhead, which is of minor importance since tenotomy of the tensor tympani has gone out of fashion.

Antagonism has commonly been asserted to exist between the action of the tensor tympani and the stapedius—the latter seeming to act upon the head of the hinged stapes so as to lift outward the front part of its foot-plate. Its nerve supply is from the facial, while the tensor tympani, like the tensor palati is enervated by the trigeminus through the optic ganglion.

The duplicature of mucosa which encloses the chorda tympani nerve backward and forward from the neck of the malleus has been already mentioned. It arises from the posterior tympanic wall near the margin of the drumhead, passes forward and with the nerve in its free edge is lightly attached to the shank of the incus and then inserts itself upon the manubrium, sometimes curving far down toward its tip. Its upper edge generally arises from the tympanic membrane in part of its course, constituting with it a wedge-shaped pouch opening downward—the "posterior pouch" of v. Troeltsch. A similar fold or continuation of this forms a smaller "anterior pouch" in front of the point where the chorda tympani is flattened against the inner aspect of the malleus-neck. While many have found in these folds nothing but the mucosa, Butler and I have seen a strong lamina of fibers like those of the membrana propria within the posterior and in one case a bony spicule, which seemed the elongated posterior cornu of the annulus. Either or both pouches may communicate with Prussack's pouch lying in front, external to the neck of the malleus; but they seem to have little physiological or pathological significance, tending to drain well; whereas the middle pouch has often very imperfect drainage-opening, which is readily obstructed by inflammatory swelling (Morpurgo) and tends to hold septic material against the neck of the malleus and provoke its caries.

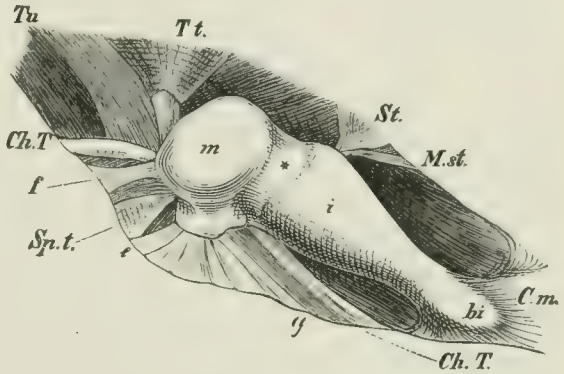


Fig. 1845.—Ligamentous Support of Ossicles seen from above. (Helmholtz.) *e,g*, Attachment of the ligamentum mallei externum; *m*, head of malleus; *i*, body of incus; *hi*, posterior attachment of incus; *Tu*, entrance to Eustachian tube from the tympanum; *St.*, stapes; *M.st.*, stapedius muscle; *T.t.*, tendon of stapedius muscle leaving the cochleariform process; *Ch.T.*, *Ch.T.*, chorda tympani, marking the free edge of the fold of mucous membrane, bounding the pouches; *f*, the upper tendinous fibers of the ligamentum mallei anterius, originating above the spina tympanica major, *Sp. t.**, malleo-incudal joint.

Much discussion has been directed to the light-spot of the drumhead and its causation. It has been previously said that the epiderm of the normal drumhead is very smooth and lustrous, reflecting much of the light which can be thrown in upon it. But the inclination of the annulus is such that all such reflection would be to the front wall of the canal, were it not for the funnel shape of the indrawn membrane. This would not suffice to bring even the lower anterior part of the drumhead to the right angle with the line of sight and illumination which is requisite that it might reflect the light back to the eye, were it not for the convex curve which exaggerates near the umbo this compensatory change of plane. Reflections from the walls of the canal and especially from the interior of the speculum, help to diffuse the illumination and thus to broaden the triangle of reflecting surface; and the light-spot has therefore its fading margins which led the earlier students to think it looked like a solid "cone of light." If the canal be cut away so that the drumhead may be viewed from any angle the arrow-head reflection may be obtained from any part of its surface (Politzer). Yet, the least variation in its contour alters at once the size and form of the light-spot, as when we study it under the pneumatic speculum; so it constitutes a most valuable means of investigating the form and surface normality of the drumhead.

B. Alexander Randall.

**Ear, Diagnosis of Diseases of the.**—The condition of each part of the ear may be determined with a fair degree of accuracy after a careful consideration of the subjective and objective materials at hand, notwithstanding the fact that the internal ear is entirely beyond the range of vision and that but little can be seen of the middle ear when it is in its normal condition. The examination of the ear is logically divided into the subjective examination, which includes the history and the tests for hearing, and the objective examination.

The SUBJECTIVE EXAMINATION embraces the investigation into the history of the case and the carrying out of the hearing tests both for the ear as a whole and for the perceptive apparatus alone.

In ascertaining the history of the case it is important to learn what is the most prominent symptom complained of, the duration of this symptom, whether one or both ears are affected, and if both, which of the two seems to be the more seriously involved. In chronic cases, when but one ear is complained of, it will often be found that both are affected though in different degrees. It is well to examine the better ear first so as to ascertain the normal direction and shape of the canal and thus facilitate a comparative test.

The duration of the affection is of importance in determining the prognosis as well as the diagnosis. The shorter the duration the better the prognosis, as a rule. The time of onset may usually be determined with accuracy in the acute cases, for these date from a "cold," from a traumatism, from one of the exanthemata, from typhoid fever, from influenza, from the expansion of a mass of cerumen, or from the introduction of a foreign body or the hatching out of maggots; while in the chronic cases, especially in those belonging to the sclerotic form of otitis media, the disease may, owing to its insidious onset, exist for a long time before its presence is noticed by the patient. The origin in such cases is often dated from the time when the tinnitus made its appearance. In other cases, however, the patient discovers by chance, long after the true onset of the disease, that he is hard of hearing in one ear. Thus, for example, he may, while lying on the good ear, miss certain familiar sounds, as the ticking of a clock. There are cases, furthermore, in which both ears have been insidiously growing hard of hearing for a long time, but in which the patient does not become aware of his deficiency until he finally observes that he has considerable difficulty in carrying on a conversation. In still other cases the patient's attention is first drawn to his ears by the development of tinnitus or by the aggravation of the defective hearing that follows a "cold." In the early stages of hardness of hearing the patient frequently complains of a confusion of words when in company; he can hear one speaker very well, but, when several are talking at the same time, he cannot distinguish the words.

The probable *cause* can in many cases be ascertained from the answers given by the patient, and such knowledge is often a decided aid to diagnosis. The important points to be learned are: (*a*) whether the affection is due to any cause which affects the ear directly, as cold, traumatism, scalds, burns, frostbite, explosions, fungi, or insects; (*b*) whether it is the sequel of some general malady, as one of the exanthemata, influenza, smallpox, syphilis, tuberculosis, diphtheria, gout, mumps, rachitis, malaria, whooping-cough, or some one of the numerous diseases of the nervous system, the lungs, or the circulatory apparatus; (*c*) whether it is the effect of some drug—usually quinine or the salicylates; or, finally, (*d*) whether it is a result of heredity, which, in the ear as in other diseases, often skips a generation. Unfortunately, there are many cases in which the cause cannot be traced.

*Earache* or *pain*, if present, is usually the most prominent symptom. If it develops in an ear that has previously been healthy, it indicates the existence of an acute inflammation of the middle ear or a furunculosis of the external auditory canal; if it occurs, on the other hand, during a chronic process, it very probably signifies the spreading of bone caries, or the damming up of pus, or the pressure caused by a cholesteatomatous mass. Pain may at times be purely a reflex otalgia dependent upon carious teeth or upon some inflammatory process in the pharynx, larynx, or tonsils, or it may in reality be a part of a trifacial or a cervico-occipital neuralgia. It may or may not be present in mastoiditis. Careful observation of the objective signs will often determine the origin of the pain. Thus, for example, pain caused by pressure on the tragus or due to drawing on the auricle indicates an inflammation of the auditory meatus; the presence of tenderness in the depression below the lobule indicates an otitis media; while a tender mastoid indicates the existence of an inflammation in the interior of that bony prominence.

*Subjective ear noises* (tinnitus aurium) occur in two-thirds of all ear cases, according to Politzer. They are probably due to pressure and irritation of the nerve endings in the labyrinth. Ear noises are variously described as singing, ringing, blowing-off of steam, hissing, rushing, roaring like the waves of the seashore, certain musical notes, clicking, or voices. In some cases the noises are heard only during perfect silence, as after retiring or when the patient is reading alone. They are especially marked when the patient is fatigued, or during a "cold," or when his general condition is below par. Noises are more common in the sclerotic form of chronic middle-ear catarrh than in the chronic suppurative conditions. In the sclerotic cases the tinnitus is frequently described as a singing or a blowing sound, and here it often precedes the deafness by many years, if indeed the latter ever follows. Tinnitus may occur in cases of aspergillus or of impacted cerumen, or it may follow the use of quinine or the salicylates. When it is due to drugs it is evanescent and probably is caused by anemia of the labyrinth. If the noises are diminished by compression of the carotid artery they are probably caused by congestion of the arterioles in the middle or external ear, and in such cases they are often synchronous with the pulse. The clicking or crackling forms of noises are generally due to spasm of the palatal muscles acting on the Eustachian tube and causing separation of its sticky walls. They may also be due to spasm of the tensor tympani or the stapedius muscle. In a certain number of cases these noises may be heard by the examiner as well as by the patient, these objective noises being more often due to aneurysm of nearby vessels. When the subjective sounds are sustained musical notes they usually represent the high A of Beethoven. Hysterical patients may describe the subjective musical sounds as "entire operas." Voices are rarely heard except in insanity. A small epithelial scale attached to the drum membrane has at times been the sole cause of distressing subjective noises. When the tinnitus intermits the prognosis is more favorable than when it is constant.

*Dizziness* or *vertigo* is occasionally due to pathological conditions in the ear. The differential diagnosis between ear vertigoes and those due to grave systemic disturbances is often of the utmost importance. As an example of this, one of the author's patients, suffering from severe vertigo, was taking 480 grains of potassium iodide daily without any relief. A large postnasal polyp was found pressing upon the left Eustachian tube mouth, and removed, with immediate relief from the staggering gait. This symptom suggests hemorrhage in the labyrinth, especially when accompanied by the chain of symptoms described by Ménière (tinnitus, nausea, vomiting, and depression). Dizziness may be a symptom in any ear disease in

which there is pressure upon the membrane of the oval or of the round window, which pressure is in turn transmitted to the nerve endings. Thus, fluid in the middle ear may be a cause, or there may be increased tension of the ossicular chain in consequence of adhesions or of an increase in atmospheric pressure upon the tympanic membrane (from occlusion of the Eustachian tube). Vertigo has also been set up by syringing the ear, or by pressure made with a probe upon the free stapes or by inflation of the middle ear. Vertigo is a symptom of labyrinthitis, and when there is no other evidence of suppurative labyrinthitis. It must be remembered, however, that vertigo from brain or other lesions may coexist with an independent affection of the ear. Impacted cerumen has been known to cause vertigo.

Discharge.—The character and duration of a discharge are important diagnostic factors. The discharge may indicate an otitis media, a furunculosis, an otitis externa diffusa—either simple or complicated by aspergillus—or a fracture of the temporal bone. Should the onset of the disease be sudden, as after a cold, bathing, or one of the acute diseases mentioned above as causes; should it be accompanied by pain and by a clear or blood-streaked serous discharge; and, finally, should the pain cease as the discharge begins, an acute otitis media may rightly be suspected. A discharge that commences without pain and becomes purulent in character indicates a tuberculous or specific condition, especially if multiple perforations of the membrana tympani are found. The quantity of the secretion varies greatly in different cases. Thus, in diffuse otitis externa or in furunculosis it is usually slight in quantity, while in acute otitis media secondary to scarlet fever, diphtheria, or influenza, in bone caries with granulations, and in mastoiditis, it is generally excessive. In the last-named condition excessive discharge of pus "pushing itself out" always means a larger area of infection than is comprised in the tympanic cavity proper, and therefore implies involvement of the antrum and mastoid cells, excepting in those rare cases where the pus has found its way into the meatus from a parotitis or other suppurating gland. Subperiosteal pockets of pus, when located in the area surrounding the external ear, nearly always mean antral involvement. The discharge is often bloody in the different forms of cachexia, in leukemia, in cases of traumatism, and in persons in whose ears there has been a postdiphthertic erosion of an artery. In bone caries it often resembles meat washings, or else it is like serum and irritating in character. In fractures of the base, and at times after operation on the stapes, there is an excessive serous discharge, which rapidly fills the meatus if it is not firmly packed. The presence or absence of odor does not throw any light upon the question as to whether bone caries is present or not, for the unpleasant smell simply indicates that there is retained discharge which is undergoing decomposition. The discharge may be continuous or it may intermit. Periodical brief discharges preceded by a pain indicate attic trouble, and a perforation of the membrana flaccida should be looked for. The color of a chronic discharge may be modified to any shade and it may contain detritus and numerous cocci, bacteria, and vibriones, together with epithelial scales when cholesteatoma is present. In some cases the objective examination reveals cicatrices, perforations, or adhesions, all of which lesions indicate that a discharge has existed at some previous time. Thus, for example, the small perforations which are found in Shrapnell's region, and which were formerly referred to as the foramen of Rivini, represent the remains of such a pathological process. After long-standing chronic suppuration much destruction of tissue may be expected. Thus, for example, large perforations in the drum membrane, and caries, or even the complete disappearance of the ossicula and neighboring bony parts, may be found.

Other symptoms commonly complained of are: stuffiness and a full feeling or a sensation of pressure in the ear.

In addition to the special points presented above, brief consideration may be given to the more general subjects of *vocation* and *habits of life*. In the case of persons who are exposed to all weathers or who are working in damp, dusty, over-heated, draughty or very noisy places, or who lead sedentary lives or have vicious habits, a more guarded prognosis as to a speedy recovery from ear disease must be given. Auditory nerve lesions are especially apt to be detrimentally affected by noises. It is well to remember that ear affections are more frequent in early childhood and in late life, that they are more common in men than in women, and that the left ear is more frequently involved than the right. About one-

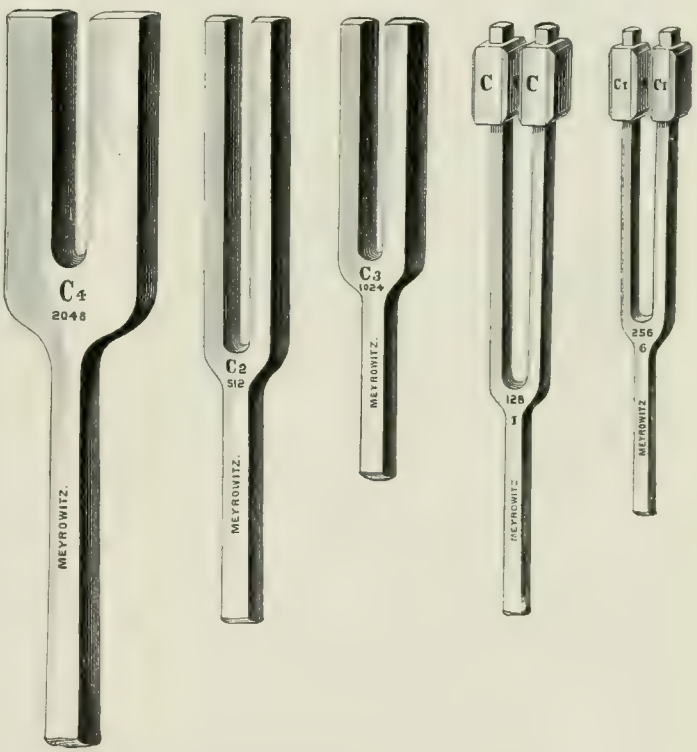


Fig. 1846.—Hartmann's Set of Tuning Forks.

fourth of all ear diseases are found in the external ear, sixty per cent. in the middle ear, and eight per cent. in the internal ear. Painful sensations (*hyperesthesia acustica*) are sometimes found in nervous people, especially in cases of slowly progressing nerve deafness. *Autophonia* or *tympanophonia* is met with when the walls of the Eustachian tube are swollen or when there is impacted cerumen in the external auditory canal. In this condition the patient's own voice sounds as if he were talking in a barrel.

*Paracusis Willisii*, or hearing better in a noise, is found more often in the sclerotic form of chronic otitis media and is therefore an unfavorable symptom;

*Paracusis localis*, or inability to locate the direction from which a sound comes, is found in marked unilateral deafness. Sudden loss of hearing is a common phenomenon in impacted cerumen, but it also often means labyrinthine syphilis. At times the pitch is altered in one ear; this is an annoying symptom in musicians and usually occurs in disturbances of the inner ear; the affected ear can be detected by holding a fork of known pitch alternately in front of each ear and having the patient imitate the sound. These cases are usually characterized by the circumstance that there is increased pressure upon the stapes in the fenestra ovalis.

Tests for Hearing.—The hearing should be tested: first, as a whole; second, as to the perceptive apparatus alone. In testing the hearing it is customary to employ the voice (words spoken in the ordinary tone and whispered), a watch which is heard in the normal ear at from fifty to seventy inches, a small clock normally heard from forty to fifty feet, a set of Hartmann's tuning forks, and a Galton whistle. Many other devices have been suggested, some of which are ingenious and of value to the expert. Among the latter may be named the universal acoumeter of Politzer, the sonometer of Hughes, the tuning forks of Blake, Lucæ, and Dench, König's cylinders, and Appunes' apparatus for determining the upper tone limits, all of which are fully described in the more comprehensive works on this subject. The normal human ear varies in its capabilities of detecting sounds, not only in different people but in the same person under different conditions. As a rule, tones of from sixteen to thirty-three thousand vibrations may be distinguished by the ear, but only those of from forty to four thousand vibrations are pleasing or musical; and the range of musical tones which the voice is capable of producing is limited to those of from fifty to eighteen hundred vibrations.

Fig. 1847.—Galton Whistle.

In treating of the hearing power as a whole, we may conveniently consider the subject under the two heads of (*a*) intensity and (*b*) pitch.

*Intensity* is most conveniently tested by a watch, clock, acoumeter, sonometer, or voice. The voice is useful to the expert, but the beginner will find the watch more practical. Each ear should be tested separately. The one not being tested should be closed by a moistened finger tip, and the eyes should be closed in order to eliminate any psychical element. The patient should first be allowed to hear the character of the sound used in testing, and then the watch should be held in a line perpendicular to the auricle, at a short distance beyond the normal hearing power, and should be gradually approached to the ear until it is heard. The hearing distance is expressed by a fraction the numerator of which is the distance at which the watch is heard by the patient under examination, and the denominator the distance at which the watch should be heard normally; thus A. D. W. D. $\frac{2}{30}$ would indicate that in the right ear the watch distance is one-half of the normal; or, in other words, since sound varies as the square of the distance, that the hearing has been reduced one-fourth. This distance may be expressed in inches or feet. Should the watch be gradually withdrawn from the ear to the farthest hearing limit, the fraction will be greater than when the above method is used, for the probable reason that the nerve endings having once been set in motion tend to continue so, while if at rest they require a louder noise to overcome the inertia and start them vibrating. It must be remembered, in this connection, that the watch may not indicate changes in the hearing power with accuracy, because while the hearing for other tones may be modified, it is possible that hearing for the tones of the watch used might not change. When the voice is used for this test the "forced whisper" from a full chest is best for comparative purposes, and, instead of fixed sentences, numbers of two figures should be used. The phonograph of Gradenigo and Urbantschitsch need simply be mentioned in this connection as having been suggested for this purpose.

*Errors in pitch* are tested by tuning forks, the Galton whistle (Fig. 1847), and other musical instruments. Hartmann's set consists of five tuning forks (Fig. 1846), as follows:

C. 128 vibrations per second for the pure tone.
C′. 256 vibrations per second for the pure tone.
C″. 512 vibrations per second for the pure tone.
C‴. 1,024 vibrations per second for the pure tone.
C⁗. 4,028 vibrations per second for the pure tone.

This set is used by Schwabach in his test. On the other hand, a very accurate diagnosis may be made by using the following instruments: a low-pitched fork, C–1, to determine the low-tone limit (or errors of the conducting apparatus); a higher-pitched fork, as C″, for determining the Schwabach, Weber, and Rinné tests (absolute bone conduction); and the Galton whistle, for determining the upper-tone limits or disturbances of hearing due to disease of the receptive apparatus. The tuning forks should be struck on a moderately soft substance (*e.g.* wood, covered with leather), in order to avoid the formation of overtones. The clamps shown on the C and C′ forks are used in order to prevent these. Galton's whistle is employed for the purpose of testing the ability of the auditory nerve fibers to distinguish tones ranging from 6,481 vibrations per second to the highest perceptible tone limit. This apparatus (Fig. 1847) consists of a steel tube of a given size in which air is caused to vibrate by means of a rubber ball fitted to one extremity, while the length of the tube may be regulated by turning the milled head at the other end. The note produced by it will become higher and higher as its length is diminished. In other words, the Galton whistle acts as a closed organ pipe in which the column of air is set in vibration and whose length may be varied at will.

The following rules, although they cannot be trusted implicitly, are of much diagnostic value when taken in connection with other points: 1. In hardness of hearing originating in the conducting apparatus low tones are often lost while high tones are usually heard well. For example, in this form of deafness thunder may not be heard while the voice is heard fairly well. In other words, the low-tone limit is raised. 2. In diseases of the receptive apparatus the high tones are lost or the high-tone limit is lowered while low tones are heard well. In such cases conversation is heard fairly well while the watch is very poorly heard and often the lower pitched male voices are heard better in nerve deafness, while female voices are heard better when the conductive apparatus is at fault. In certain diseases, in which there is increased pressure on the auditory nerve, both high and low tones may be lost while middle tones are heard fairly well.

By applying the above rules to the results obtained by the forks named (C–1 or Dench adjustable fork for low tones, and Galton whistle for high tones), the condition can be diagnosed.

*Testing the Hearing Power in the Perceptive Apparatus Alone.*—Among the tests used to determine whether the defects in hearing are due to nerve lesions or to alterations in the conducting apparatus are those of Weber, Rinné, Gellé, Bing, Schwabach, and Gradenigo.

The *Weber test* consists first in holding the handle of the tuning fork (512 vibrations or lower) on the median line of the skull or against the incisor teeth or the symphysis of the mandible; then, if the vibrating fork is best heard in the deaf ear, the trouble is in the conducting apparatus and if best heard in the better ear the trouble is in the perceptive apparatus.

*Rinné's Test.*—Rinné first ascertained that the normal ear heard the vibrating tuning fork through the air—*i.e.* when the fork was held before the ear—about twice as long as when its heel was pressed on the mastoid process—*i.e.* when the vibrations were transmitted through the bone. He found, however, that when the conducting apparatus is obstructed, the vibrations can be heard louder and longer with the fork in contact with the mastoid than through the air. In the Rinné test, therefore, the vibrating fork is held alternately before the ear and in contact with the mastoid process; and if the sound of the fork is heard louder and longer through the air than through the bone, in a partly deaf ear, it is permissible to infer that the lesion is located in the perceptive apparatus. On the other hand, if, in a similarly deaf ear, the sound is heard better through the bone, it may rightly be concluded that the lesion is in the conductive apparatus. The C″ tuning fork is commonly used for this purpose because if properly made it is free from overtones. When the loss of hearing is slight the watch may be used, and if its ticking is heard when it is placed on the mastoid, between the teeth, or on the forehead, and not heard in front of the ear (through the air), the defect of hearing—it may be inferred—is in the conducting apparatus.

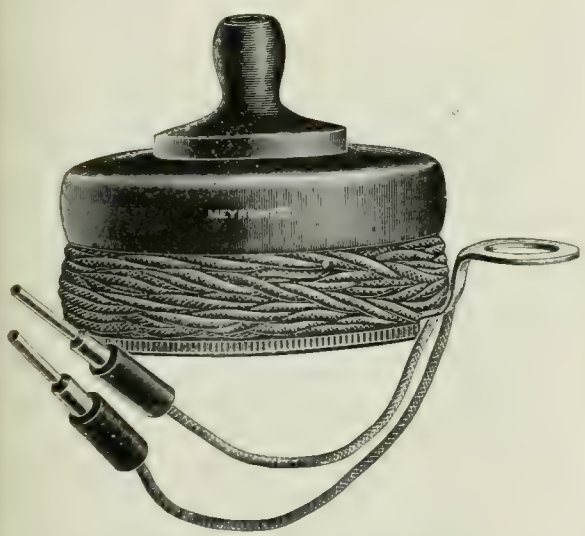

Fig. 1848.—Neuman's Suppression Apparatus. This instrument consists of a hard-rubber case with an ear-piece for insertion in the external meatus. Connected to an ordinary faradic battery it produces a loud buzzing which makes the ear it is applied to deaf to external sounds. Used to secure suppression of one ear during the examination of the other.

*Gellé's test* is for the purpose of ascertaining the mobility of the stapes in the oval window. It depends upon the fact that, if the foot plate is movable, compression of the air in the external canal will cause the sound from a vibrating tuning fork held on the skull to be diminished or lost, while if the foot plate is not movable there will be no change in the intensity of the sound.

*Bing's test* is a modification of Weber's.

*Schwabach's test* consists in measuring the actual time of hearing each of the different vibrating forks on the mastoid and before the ear, tabulating these periods of time and applying the rules given above. Schwabach uses, in making this test, the five Hartmann's forks.

In nerve deafness the conduction through air is better than that through bone, although the absolute duration of both is reduced. Bone conduction is usually decreased in the aged, as the auditory nerve is then somewhat defective. In all tests for bone conduction diseases of the external ear should be eliminated by inspection. In purulent labyrinthitis the hearing is totally destroyed in the affected ear, if the inflammation is diffuse. In order to determine this total loss of hearing it is necessary to eliminate the hearing power of the normal ear by the use of the sound producer (Fig. 1848).

The vibrating tuning fork C″ has been used, according to the suggestion of Politzer, as a means of testing the permeability of the Eustachian tube. For this purpose the vibrating fork should be held in front of the nostrils during the act of swallowing. If the sound is then heard better in one ear, the opposite Eustachian tube is probably closed. In this test, however, the fork may be heard better in the worse ear if it happen to be the seat of a sclerotic otitis media with an open tube. An elaborate system of tests for investigating the irritability of the vestibular or labyrinthine apparatus has been recently devised and carefully gone into by Neumann of Vienna.

The Objective Examination.—The objective examination consists of a careful inspection of the periotic region, the external ear, and as much of the middle ear as is visible. This is done with the aid of a strong

Fig. 1849.—Points of Mastoid Tenderness in Acute Mastoiditis. The uppermost X is over the site of the mastoid antrum, the lower one is over the mastoid tip, and the posterior one is over the point of exit of the mastoid vein. The hair of the whole head is clipped close and the mastoid region is closely shaved preparatory to the mastoid operation.

light and certain instruments of precision, and confirms the subjective examination. The nose and rhinopharynx should be thoroughly examined, in the manner described elsewhere in this treatise, so as to determine their relationship to the diseased ear.

Inspection by the naked eye, aided by concentrated light, should detect any skin lesions (eczema, furuncles, etc.), errors of development, traumatism, tumors or new growths, and variations from the normal color. By the aid of palpation any tenderness, bogginess, or fluctuation may be detected. Tenderness from

pressure on the tragus would imply inflammation of the meatus, while the same sensation caused by pressure made below the lobule would point rather to inflammation of the middle ear. Tenderness over the mastoid indicates inflammation in that region. The points of mastoid tenderness in acute mastoiditis are (1) over the site of the antrum, (2) over the point of exit of the mastoid emissary vein, and (3) over the mastoid tip, as indicated in Fig. 1849. So, too, palpation is competent to determine the consistence of tumors or swellings. A rigid, cord-like swelling along the anterior border of the sternocleidomastoid muscle has often been cited as one of the important signs of sinus thrombosis but it is more often absent than present.

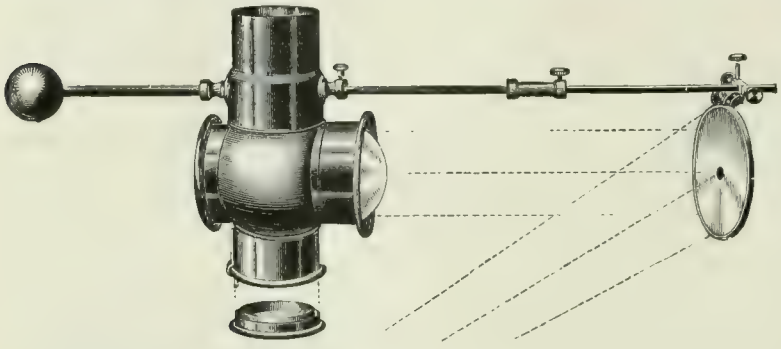

Fig. 1850.—McKenzie Condenser. May be fitted to an adjustable bracket with Argand burner, Welsbach light, or electricity, or both, so that if one fails the other may be immediately switched on.

*Illumination.*—Daylight or artificial light may be used, either directly or indirectly. Daylight, when obtained from a light cloud, is excellent, but, inasmuch as it is available only at certain times, it cannot be depended upon. Direct light may be used in the ear in emergencies when there is no mirror at hand, but its value, except for the examination of external parts, is small. Indirect artificial light furnishes the form of illumination most commonly employed. The source of light may be a candle (or, what is better, three candles), a kerosene lamp, gas, or an electric light. The Welsbach light is the better form of gas light. When any artificial light is used allowance must be made for the changes in color due to the source, the reds and yellows being slightly exaggerated in all artificial lights. In practice the light is usually reflected by a centrally perforated concave mirror (Figs. 1850 and 1851). The mirror should be about three and a half inches in diameter and suspended from a headband or a movable bracket attached to the wall. Such a mirror will focus parallel rays at from seven to ten inches. For office work a good combination of light and reflector is that shown in Fig. 1850. In this contrivance the light (Argand, Welsbach, or electric lamp) is condensed by the condenser on the mirror, which in turn focuses the rays upon the point to be examined. The bracket may be raised or lowered by a screw. For bedside work the mirror should be suspended from the headband (Fig. 1851) while the light should occupy a position slightly above the level of the patient's ear and as nearly in the vertical plane that embraces the eye of the observer and the ear to be examined as is possible without allowing the patient's head to interfere with its rays. The joint that connects the mirror with the headband should be so arranged as to allow the former to be moved in all directions, thus rendering it possible to bring it close to the observer's eye and to turn it in such a direction that it shall throw the rays upon the spot to be examined while yet permitting the examiner's head to remain in a position of ease and comfort. A convenient bedside light is the portable apparatus described by Dench ("Diseases of the Ear," p. 77), or Freeman's electric head mirror (Fig. 1852).

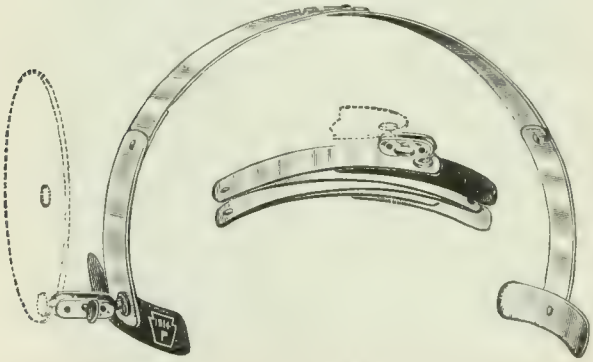

Fig. 1851. Headband Made of Steel Segments, which fold as in cut or fold over the mirror, thus protecting it.

A *speculum* of some kind is essential for the thorough examination of the fundus. Specula may be made of various shapes and materials, as pictured in the catalogues of the instrument makers; those which have the largest internal caliber with a given external size being the better. Gruber's specula made of sterling silver, with the small end oval-shaped and the large end circular and milled to facilitate rotation, are very convenient. They have a double longitudinal curve as indicated in Fig. 1853 and may readily be sterilized. The naked-eye examination having been completed the speculum is introduced into the external auditory canal, which is then examined as well as the tympanic membrane and fundus. The better ear should be examined first, for purposes of comparison.

Fig. 1852.—Freeman's Electric Head Mirror.

*Introduction of the Speculum.*—In the case of an adult the auricle should be grasped between the index and middle fingers of the opposite hand (the index finger in front) and drawn gently but firmly upward, backward, and outward, so as to straighten the canal. In children, on the other hand, the auricle should be drawn downward, backward, and somewhat outward, in order to open and straighten the meatus. The warmed speculum should then be gently inserted with the thumb and index finger of the right hand by a rotary motion (Fig. 1854), care being exercised to prevent its turning up scales of epithelium or detritus in the line of vision. It should be pushed on into the cartilaginous canal as far as possible, but not into the bony part, as this region is exceedingly sensitive to pressure on account of the thinness of its soft parts. In certain cases the presence of the speculum in the canal excites a reflex cough due to irritation of the auricular branch of the vagus (Arnold's nerve) which is transmitted through the superior laryngeal to the muscles of the larynx. Fainting fits or epileptiform convulsions are said to have occurred from the simple introduction of the speculum. The vibrissæ having been pressed aside the state of the meatus may be noted as to size, shape, secretion, and blood supply. The state of the cerumen, whether dry or moist, and the presence of such pathological conditions as seborrhea, eczema, traumatism, pustules, furuncles, pus, blood, fungi, exostoses, foreign bodies, or polypi, should all be noted. Fungi are apt to be overlooked and furuncle must be differentiated from otitis media or mastoiditis. The eye should be over the central orifice of the mirror which should be exactly focussed upon the point under observation. The position of the speculum should be changed from time to time so as to bring each part of the canal and membrana tympani into view. In this examination the eye is aided by a probe made of light tapering steel, the tip of which is barely covered with cotton. The probe enables the observer to remove particles of epithelium, detritus, or cerumen from the line of vision and at the same time to judge of distance, which of course could not be estimated by the single unaided eye. For the removal of large masses of detritus forceps should be used (Figs. 1855 and 1856), and of these several patterns should be at hand: one with blades that open in the vertical plane, and another with blades that open horizontally. The various shapes of the normal canal must be borne in mind, and especially should it be remembered that on the anterior inferior wall there is often a decided lump which may nearly shut out a view of the anterior portion of the membrana tympani.

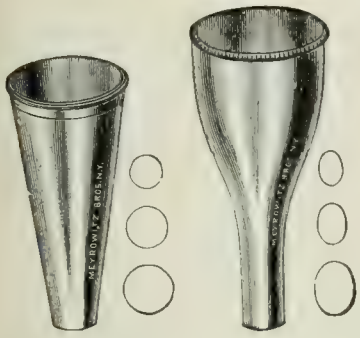


Fig. 1853.—Ear Specula. 1. Wilde's. 2. Gruber's. They are made in nests of three or four, and may be either of metal or of vulcanite.

Fig. 1854. Introducing the Speculum and Examining the Parts by Means of a Slender Probe.

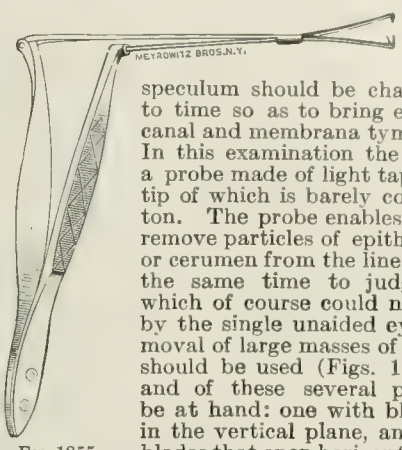


Fig. 1855.—Sexton's Forceps, which may be fitted with various end pieces.

*The appearance of the membrana tympani* varies greatly in different subjects, even when the hearing power is normal. The light spot, for example, is blurred in about eighty-six per cent. (Bezold) of healthy ears; the obliquity of the drum membrane is less evident in wide than in narrow canals and less marked in the living than one would expect after seeing the dissected specimen. In childhood the membrane is usually lusterless and in old age it is often gray normally.

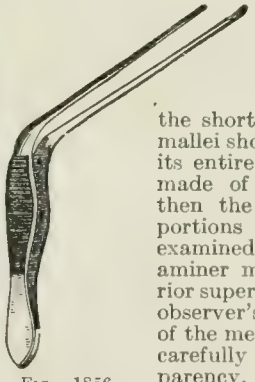

Fig. 1856.—Wilde's Angular Forceps.

Briefly, then, after the walls of the canal have been surveyed, the eye should be focussed upon the different parts of the membrana tympani in succession: first, the short process and the manubrium mallei should be scrutinized throughout its entire length, and a note should be made of any existing abnormalities; then the peripheral and intervening portions of the membrane should be examined, and in doing this the examiner must not forget that the posterior superior portion is much nearer the observer's eye than is any other portion of the membrane. He should also note carefully its shape, color, luster, transparency, opacity, and degree of vascularity. The region of Shrapnell's membrane must also be carefully studied and the presence of chalky deposits, perforations, cicatrices, bulgings (from the presence of fluid back of the tympanic membrane), granulations, polypi, etc., must not be overlooked. In the absence of the membrana tympani and ossicles, it is often impossible to tell, by simple inspection, whether one is viewing a congested drum membrane or the mucous membrane of the promontory. This difficulty, which is due to the lack of perspective which exists when only one

eye is used, can be overcome only by the use of a suitable probe.

The Siegle speculum (Fig. 1857) will aid one in clearing up many obscure points. It consists of a speculum, the smaller end of which is surrounded by a piece of soft-rubber tubing by means of which it may be inserted air-tight into the external orifice of the auditory canal, while the outer flaring end is closed by a plate of glass set obliquely. It has a nipple which projects from its side, and over this is slipped a rubber tube, whose other extremity is attached to a rubber ball or a Delstanche rarefacteur. This instrument should be carefully inserted into the meatus and the air alternately exhausted and condensed by means of the bulb, rarefacteur, or the mouth applied to the tube end.

Normally, the drum membrane should follow the impulse of the air, moving inward when it is condensed and outward when it is rarefied, and such movements would be most apparent in the postero-superior quadrant. In such cases the tip of the malleus is revolved about the folds as an axis unless adhesions happen to be present, in which case their location is made evident by the absence of the normal movement. Thus, if the tip of the malleus is bound down by intratympanic adhesions, it will evidently not move outward, although there may be bulging of the membrane in front and behind and although the short process may move slightly outward if there is relaxation at that point.

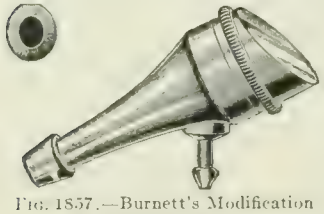

Fig. 1857.—Burnett's Modification of Siegle's Speculum.

If the ossicular chain and the drum membrane as a whole are drawn inward by extensive adhesions the malleus may be revolved on its long axis.

Frequent observations will acquaint the surgeon with the normal range of these excursions of the various parts of the membrane and the malleus.

*The nose and nasopharynx* play a part in the etiology of most diseases of the ear. They should, therefore, be carefully examined according to the rules set down in the proper place in this work.

The nasopharynx is the vestibule of entry for the middle ear, not only in so-called "colds" but in measles, scarlet fever, diphtheria, influenza, smallpox, pneumonia, and many other diseases. A careful search must therefore be made for stenoses of the nares or nasopharynx, for hypertrophic or atrophic conditions, ethmoiditis or sinus disease, and for other abnormalities, such as polypi, exostoses, deflections, etc.; and if irregularities are found to exist they must be corrected before the best results will be obtained in the treatment of ear diseases. Posterior rhinoscopy also furnishes evidence of the condition of the orifices of the Eustachian tubes—whether swollen or atrophied, or whether adenoids or cicatricial bands are present.

Examination of the Middle Ear.—The presence of evidences of disease in the middle ear and the permeability of the Eustachian tube can be ascertained by the aid of various methods of inflation, which are also at the same time important therapeutic procedures. The methods of inflation are: (*a*) The Valsalva method; (*b*) catheterization, in which bougieing may be included; and (*c*) Politzer's method. In each of these methods—but more particularly in the last two—the nose and nasopharynx should be thoroughly cleansed, and the Eustachian tube orifices should be wiped out with a curved cotton-tipped probe which has been dipped in some antiseptic astringent, or alterative preparation, *e.g.* argyrol, glycerol of tannin, iodine, etc., introduced through the mouth and up behind the soft palate.

(*a*) *The Valsalva Method* consists in compressing the air in the nasopharynx by forcing it up from the lungs when the nostrils are compressed between the thumb and fingers. While easily applied and of some diagnostic value this method is not an entirely safe therapeutic procedure. The entrance of air into the middle ear may be detected by the changes in the appearance of the membrana tympani and especially in the light cone, which may disappear entirely. The malleus often moves outward, and so also does the part of the membrane between it and the periphery. The air passes more easily when there is a perforation in the tympanic membrane.

Fig. 1858.—Auscultation Tube, for Use in Examining the Middle Ear.

An *auscultation tube* consisting of a simple rubber tube (Fig. 1858), one end of which is placed in the observer's and the other in the patient's ear, may be used to test the passage of air. As the tympanic membrane bulges outward a short blowing sound reaches the ear of the observer. In cases of perforation of the tympanic membrane there will be a hissing or whistling sound if the air is not impeded in passing through the Eustachian tube.

(*b*) *Catheterization of the Eustachian Tube* consists in the introduction of a catheter into the pharyngeal extremity of this tube, an operation which is usually accomplished by way of one of the nasal passages, although it may also be effected by way of the mouth. The Eustachian tube may be regarded as a continuation of the inferior meatus of the nose, although the mouth of the tube is usually distinctly outlined by the fold of mucous membrane and the cartilage which bound it above and on either side. At times, however, catheterization is rendered difficult on account of the presence of cicatricial bands, of excessive lymphoid tissue, of posterior turbinated hypertrophies, of polypi or of septal deformities. It is at best a most delicate operation and requires a gentle and highly educated touch. The instrument to be used (Fig. 1859) may be made of any metal or of vulcanite, the latter being necessary in cases in which it is desired to apply electricity through the catheter. For diagnostic purposes the catheter made of pure silver is preferable; its tubal end should be well rounded or somewhat

Fig. 1859.—Eustachian Catheter of Vulcanite or Metal. (About one-half natural size.) Several sizes are available, as shown at *a*.

bulbous to protect the soft parts, and the outer end should have a milled head, to facilitate the rotation of the instrument, and an eyelet to indicate the direction of the tip. With a metal catheter a larger caliber is obtained for a given outer diameter, and those made of pure silver are more desirable on account of their greater pliability. The catheter must be thoroughly sterilized before and after use, and an instrument which has been used on a syphilitic patient should never be used on other patients.

A number of methods have been advocated for the introduction of the catheter and of these the ones which I am about to describe are, I believe, the most useful. They are named in the order of their relative merit, although any one of them may be necessary in a given case.

(1) The posterior edge of the vomer is the guiding

landmark in Löwenberg's method. The nose and nasopharynx should be carefully cleansed as above described, the irregularities in them should be noted, and the patient's head should be in a natural vertical position. If the nasal irregularity is great, leaving little room between the inferior turbinate and the septum, or if the patient is nervous and shows a marked aversion to the introduction of the catheter, a cotton-tipped probe bearing a weak cocaine-adrenalin solution may be passed through the inferior meatus to open and anesthetize it; but this solution should not be allowed to reach the mouth of the tube lest the topography be marred. The tip of the nose should be tilted up by the thumb of the operator's left hand, while the other fingers rest for support on the bridge of the nose, or upon the side of the head, as shown in Fig. 1860. The aseptic catheter, warmed and properly oiled, should then be lightly held like a pen, or between the index and middle fingers, with the flaring end resting against the thumb (as shown in Fig. 1860), at an angle of about sixty degrees or parallel with the nose; then, under good illumination and with great gentleness, the tubal extremity of the instrument is to be steered along the floor of the nose while the shaft is allowed to rest upon the floor of the vestibule. When the tip reaches the pharyngeal wall, or is felt to glide over the velum, it is to be rotated toward the median line and the catheter drawn out until the point is caught by the septum. Then, without further longitudinal motion, the tip is to be revolved downward and outward, through an angle of somewhat more than 180°, when it will be felt to bring up in the mouth of the tube, at about the same time that the eyelet in the outer extremity points to the outer canthus of the eye. The position of the catheter in the tubal orifice may then be verified by a gentle blast from the Politzer bag or from the compressed-air tank. The milled head of the catheter should then be grasped with the thumb and index finger while the other three fingers rest upon the bridge of the nose to steady it.

Fig. 1860.—Introduction of the Catheter.

(2) In the second method the catheter is introduced in the same way as in the first until the pharyngeal wall is reached, when the tip is turned outward into Rosenmüller's fossa and the instrument gently drawn out until it is felt to slip over the posterior lip of the Eustachian orifice, into which it may then readily be turned. This method is not entirely sure or easy to carry out when the posterior lip is small or flat, as sometimes results from ulceration or from atrophy, or when the anatomical relations of the nose or pharynx are such as not to allow of the tip of the catheter being drawn along the pharyngeal wall. This procedure is also difficult to carry out in the presence of edema or when there are adenoids, polypi, or hypertrophies of the posterior extremity of the turbinates. The posterior lip of the tubal orifice may at times be so prominent that the catheter cannot be slipped over it, and in other cases the beak of the instrument may be drawn too far forward and thus pass in front of the anterior lip.

(3) A third and rather uncertain method consists in introducing the catheter as before until the pharyngeal wall is reached, when the instrument is drawn outward about three-quarters of an inch and the point turned from its downward position through an angle of about 135° until it enters the pharyngeal mouth of the Eustachian tube. It will be readily seen that adenoids, atrophy, or any irregularities of the pharyngeal wall would entirely eliminate accuracy from this method, which is in far too common use.

(4) The expert often introduces the catheter in the manner stated above, gently turning the point outward before the pharynx is reached, and thus lightly guiding it into the tubal orifice by the sense of touch upon the outer wall of the meatus and the pharynx without stopping at any special landmark. This, of course, can be done only with highly educated fingers.

(5) In certain cases, it may be necessary to catheterize through the opposite nostril. For this purpose a more acute angle is given to the tip of the catheter, which is then revolved into Rosenmüller's fossa, drawn over the posterior lip of the tubal orifice, and pressed into the ostium tubæ.

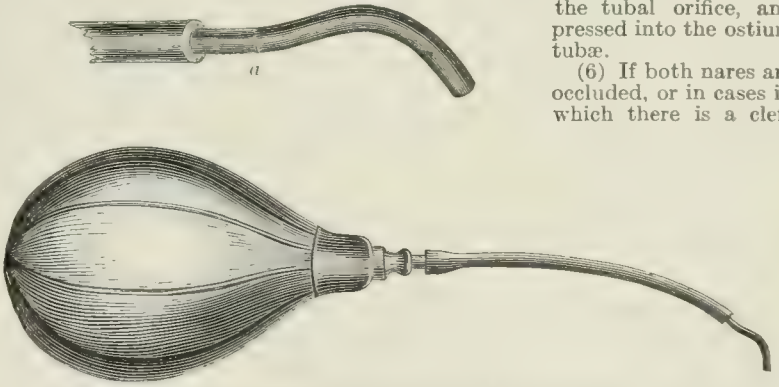


Fig. 1861.—Politzer's Apparatus, complete (one-third natural size). *a*, Nosepiece (natural size).

(6) If both nares are occluded, or in cases in which there is a cleft palate, a catheter with a special bend for the cases at hand may be introduced through the mouth into Rosenmüller's fossa and slipped over the posterior lip. A two-per-cent. solution of cocaine wiped over the back of the velum may aid in this little operation, which, fortunately, is rarely necessary.

After the catheter has been successfully intro-

duced, air is sent through it into the middle ear by the aid of a Politzer bag or a tank containing compressed air.

The pear-shaped *Politzer bag* is made of soft rubber and should have a capacity of about eight ounces; it should have no valve, and the outlet should be spherical so that the opening may be brought over the end of the catheter without the nozzle or end-piece slipping into the catheter. Jamming and consequent jarring will thus be avoided. An ingenious attachment has recently been invented for regulating the pressure of the compressed air as it comes from the tank. Owing to this invention the Politzer bag has been superseded to a great extent as a means of forcing air through the catheter. Air, chloroform, or iodine vapor may be forced into the catheter from the bag or tank. At first this should be done gently, in order to preclude traumatism and consequent emphysema; but afterward several blasts should be given in quick succession. If the Eustachian tube through which the air is thus forced is patulous and the catheter is rightly pointed in the ostium, clear of folds, the auscultation tube should transmit a clear sound to the ear of the observer. The advantages of the tank over the Politzer bag for purposes of catheterization are: nicety of regulation of pressure; the cut-off need not be removed from the catheter between the successive blasts, as is necessary when the Politzer bag is used, and hence unnecessary jarring is avoided; the air may be heated or medicated when the tank is used; a steady current may be kept up if deemed advisable. The patient's own sensations are not always accurate as to the passage of air into the middle ear. In such cases the auscultation tube or a manometer may be used. To use the auscultation tube intelligently one must be familiar with the blowing sound (bruit de pluie) which is transmitted to the observer's ear in normal cases and its many modifications.

(*c*) *Politzer's Method of Inflation.*—Politzer's method does away with the catheter and has not the disadvantages of Valsalva's method. In fact it may be regarded as the routine method, the use of the catheter being restricted to obstinate cases in which Politzer's is not effective, or to those in which it seems desirable to pass medicaments or the bougie through the instrument, or cases where it is desirable to inflate one ear only. The end-piece originally recommended by Politzer and still preferred by many otologists is that represented in Fig. 1851, *a*. Other authorities give the preference to a straight or an olive-shaped end-piece. For young children the latter pattern is unquestionably preferable. A rubber tube eight or nine inches in length serves to connect the end-piece and the bag. This method of inflating the ears depends upon the compression of the confined air in the nasopharynx, which air is forced in the direction of least resistance into the Eustachian tubes. In this method the end-piece or nozzle is entered into one naris and both nasal orifices are then closed anteriorly by compression between the thumb and fingers while the nasopharynx is shut in by approximating the palate against the pharyngeal wall. The latter is accomplished by the act of swallowing, by pronouncing certain words as "huck" or "hock," or by puffing out the cheeks balloon fashion. When swallowing is the method employed, only a small quantity of water is used and the bag is compressed at the moment the pomum Adami is seen to rise. The soft palate, during the act of swallowing, is closely pressed against the pharyngeal wall and the Eustachian tubes are drawn open by the palatal muscles. Previous to compressing the bag the patient should be warned of the shock to be expected, and, in order that this may be as slight as possible, the Politzeration should be done very gently at first. The air will often enter both ears when one tube is swollen, but it will enter on the diseased side with less force. Frequently the patient is unable to tell whether or not the air has passed. When chloroform vapor is used a sense of "heat" or "cold" is felt. In children the act of crying, or often the reflex from the impact of the air upon the soft palate, will throw the latter up and thus close the nasopharynx; in any event Politzeration is more easily accomplished in childhood because the Eustachian tubes of children are shorter and wider than are those of adults.

Fig. 1862.—Politzer's Method of Inflating the Middle Ear.

Many modifications of Politzeration have been suggested. Condensation of air in the external meatus may be useful to discover perforations when other methods fail. This may be accomplished by placing the olive tip of Politzer's bag in the meatus and compressing the bag.

The Diagnosis of Mastoiditis.—Inflammation of the mastoid antrum and mastoid cells is, in the great majority of cases, secondary to an inflammation of the tympanic cavity, although very rarely it may be primary, as when due to traumatism.

Mastoiditis may occur in either the acute or chronic form. The diagnosis is reached by consideration of the general physical condition of the patient, as well as by the changes which are found over the mastoid process, in the neighborhood of the external ear, and in the middle ear.

*Acute Mastoiditis.*—The cases of middle-ear suppuration which proceed to mastoid involvement are usually ushered in by symptoms more severe than those occurring in the milder forms of the disease. The patient is more prostrated in the virulent types which are followed by mastoiditis. There is more apt to be loss of sleep and disturbed digestion than in the simpler forms of otitis media purulenta.

Temperature changes are of little value in cases of simple mastoiditis, although in children the temperature is more often elevated. In cases of sinus thrombosis the temperature is apt to vary markedly in the course of twenty-four hours, often passing through one or more cycles of very high and low temperature in the twenty-four hours. In meningitis secondary to mastoiditis, the temperature is apt to be high, varying from 101° to 106° while in brain abscess the temperature is usually subnormal, normal, or slightly elevated.

*The External Manifestations.*—The mastoid region may be swollen, boggy, and reddened, with possibly a higher temperature over the diseased mastoid than over the other side, and there is usually pain and tenderness, the pain at times extending over the whole side of the head. There is more or less discharge from the ear. The *swelling* is apt to cause the disappearance of the auriculomastoid skin fold, and to push the auricle outward, forward, and downward. Marked swelling, with fluctuation, is found in those cases where the pus has ruptured through the external bony wall of the mastoid, although there is often bogginess as a result of the infiltration of the soft tissues through the vascular channels. On the other hand, where the outer table is very thick, there may be no swelling whatever. *Tenderness* is usually found over the mastoid antrum, over the mastoid tip, the

zygoma, and over the point of exit of the mastoid emissary vein (Fig. 1849).

The quantity and character of the otorrhea are of value. A case of acute suppurative otitis media, in which the discharge continues from three to six weeks in spite of careful treatment, may be considered as having become chronic; and if the amount of pus is large, "pushing its way out of the meatus," the mastoid antrum will be found to contain pus.

Examination of the fundus usually shows a reddened tympanic membrane, with a small perforation in the superior half. If the bead of pus protruding from the perforation is wiped away, another will protrude almost at once, owing to the pressure in the tympanic cavity. If the otitis is very virulent, as in post-grippal or scarlatinal cases, the tympanic membrane and ossicles may be destroyed early in the disease, and there may be extensive mastoid involvement within twenty-four hours of the onset.

Bulging of the upper segment of the drum membrane, and swelling in the fundus of the canal over the region of the anterior antral wall (that is, the postero-superior internal portion of the external meatus) is regarded by many as a pathognomonic sign. This swelling can usually be readily detected, as it gives a peculiar rectangular appearance to the fundus of the canal.

The differential blood count is often of value in that a marked increase in the leucocyte count and a high polymorphonuclear count, in connection with the other symptoms of the disease, tend to confirm the diagnosis of purulent mastoiditis. The bacterial examination of the pus may aid in determining the probable severity of the disease and its prognosis.

*Differential Diagnosis.*—In the edema over the mastoid process, secondary to *furunculosis*, severe pain is evoked by any manipulation of the auricle, and the skin over the mastoid process can be pitted more readily by pressure than in the edema of mastoiditis. Inspection of the external auditory canal establishes the diagnosis. So, too, pain and swelling about the mastoid process, due to inflammation of the lymph glands, are eliminated by inspection of the canal. When the external swelling is toward the posterior border of the mastoid process, in the neighborhood of the mastoid emissary vein, it suggests deep-seated disease of the mastoid process, or, possibly, sinus thrombosis, or other intracranial complications. When the swelling extends below the mastoid process along the muscles of the neck, it suggests rupture into the digastric fossa, or Bezold's mastoiditis. Brawny swelling over, above, and posterior to, the jaw seems to imply involvement of the lateral sinuses.

*Chronic Mastoiditis.*—In chronic mastoiditis the suppurative process of the middle ear is continued over a long period of time. The symptoms are often not pronounced and frequently consist merely of a history of long-continued discharge, with or without occasional attacks of pain in the ear or over the side of the head. Pain, vertigo, nausea, nystagmus, facial paralysis, are at times met with as sequelæ. The otorrhea varies in amount, sometimes being so profuse as to fill the auditory meatus several times daily, while at other times being so scanty as not to appear externally at all, drying in the fundus before it has had sufficient time to appear externally. In these latter cases it must be detected by inspection of the fundus, as the patient is aware of its presence only during such exacerbations as are caused by "taking cold."

The pus may be mucoid, as when the neighborhood of the Eustachian orifice is affected; it may be sanious, as when highly vascular polypi are present; it may be extremely fetid, as is the case in cholesteatoma, or when there has been much retention; or it may resemble stringy "meat-washings" when there is extensive bone caries.

In these cases of long-continued suppuration the bacteriological examination usually shows mixed infections. With the history of frequent exacerbations of mastoid inflammation, there may be constant tenderness over the mastoid process and side of the head with or without such periodical pain. On the contrary, there may be no history of pain whatever in cases of most extensive mastoid caries at times resulting in the complete destruction of the mastoid process. Vertigo, more or less constant, not caused by pressure over the oval window, usually implies labyrinthine involvement. Nystagmus, or strabismus, occurring in these cases, would lead one to suspect intracranial extension. Choked disc is very often found with cerebral or cerebellar complications.

Facial paralysis, when present, is caused by pressure of cholesteatoma, sequestra, or exudate about the nerve sheath in the Fallopian canal; or it may be due to an extension of the infection directly to the nerve trunk. The tinnitus aurium is seldom so severe as that which accompanies chronic non-suppurative inflammations, although it may be present when the foot-plate of the stapes is bound fast by adhesions secondary to the suppurative process. In these cases the hearing power varies, but is usually not markedly deficient, even when the destructive process has been very extensive as to tympanic membrane and ossicles, excepting in cases where there has been labyrinthine involvement. In these latter cases deafness is sometimes complete.

*Physical Examination.*—The neighborhood of the auricle should be examined for swelling, tenderness or fistulæ; the external canal for a thickened, fissured, or eczematous condition. Pus, dry or moist, will be found in the fundus. The perforation of the tympanic membrane may be of any shape or size or position, single or multiple. Generally speaking, however, peripheral perforations are found in these cases of chronic mastoiditis. Multiple perforations imply syphilitic or tuberculous infections. Epithelial detritus or cholesteatoma may often be dislodged from points superior and posterior to the line of sight. Polypi are often found, and they are apt to recur rapidly after removal, if the necrotic process is active.

In cases of extensive necrosis the landmarks may be almost entirely obliterated, although the stapes is seldom destroyed. The carious process usually attacks the incus first, then the malleus, then the scute, then the region of the aditus, and lastly, the promontory. The disease may progress to almost complete destruction of the petrous portion, and involvement of the zygoma, and may, indeed, pass beyond the limits of the temporal bone. Not infrequently the pressure necrosis from a cholesteatoma will transform into one large cavity the antrum, the tympanic cavity, and the fundus of the osseous canal.

In *sinus thrombosis* the diagnosis is difficult, and often impossible. All the symptoms enumerated above may be present. The pain may be referred to the neck, or enlarged cervical glands, and at times there is a general tumefaction over the side of the neck and angle of the jaw, following sinus involvement. In the typical cases of sinus infection the temperature passes through cycles in which there is a rise to 102° to 106° or higher, followed by a remission to normal, or near normal, this occurring one or more times in the twenty-four hours, the rise being usually preceded by a chill, and the fall by severe sweating, the pulse-rate varying with the temperature. The general asthenia is more marked than in cases of simple mastoiditis, although the mentality is often unaffected throughout the entire course of the disease. Vomiting of a cerebral character is often met with. Emboli from the septic clot sometimes cause pneumonia or general pyemia.

*Otitic Brain Abscess.*—The prominent symptoms of brain abscess are, pain, vomiting, slow pulse, normal or subnormal temperature, rigors, intraocular changes, cessation of the aural discharge, slow cerebration, with paralysis of certain groups of muscles.

The slow pulse and the normal or subnormal temperature are probably the best aids in diagnosis. Chills are of less frequent occurrence than in sinus thrombosis. The sallow, worn face, emaciated body, putrid odor of the breath, and marked asthenia, tend to make one suspect brain abscess.

Photophobia, inequality of the pupils, diplopia, optic neuritis, are sometimes found. Drowsiness and a generally dull mental state are often present. But while the foregoing are the classic symptoms, the diagnosis of intracranial abscess, with our present knowledge, is a most difficult problem.

*Meningitis.*—In meningitis of otitic origin the temperature is usually high (102° to 106°) but is sometimes moderate, with gradual remissions. The pulse is greatly accelerated; the pain in the head, especially over the forehead, is severe; and there is pain in the neck, which is usually stiff and immovable. Chilliness, or chills, may occur, but not so frequently as in sinus thrombosis, although probably more frequent than in brain abscess. Vomiting of the cerebral type occurs, independent of the ingestion of food: thus resembling the same symptom in brain abscess. The respirations are rapid, in contradistinction to the slow and fuller respirations in brain abscess. There is often rigidity of the muscles of the abdomen and back, and sometimes general convulsions—conditions which rarely occur in sinus thrombosis and brain abscess. In the early stages the patient is apt to be irritable. Kernig's sign is present probably in eighty to ninety per cent. of cases of meningitis, and is absent in sinus thrombosis and brain abscess.

George C. Stout.

**Ear: Diseases of the Acoustic Nerve and Labyrinth.**—For years the internal ear (the labyrinth) has been a fertile field for a host of investigators. At last a stage has been reached enabling us to collect a series of facts, theories, and tests on which our present knowledge of labyrinthine conditions is based. To appreciate the subject thoroughly, one must be versed in the functional tests and know the main facts and theories. The following is a résumé of the entire subject, a careful study of which will facilitate an intelligent handling of internal ear conditions.

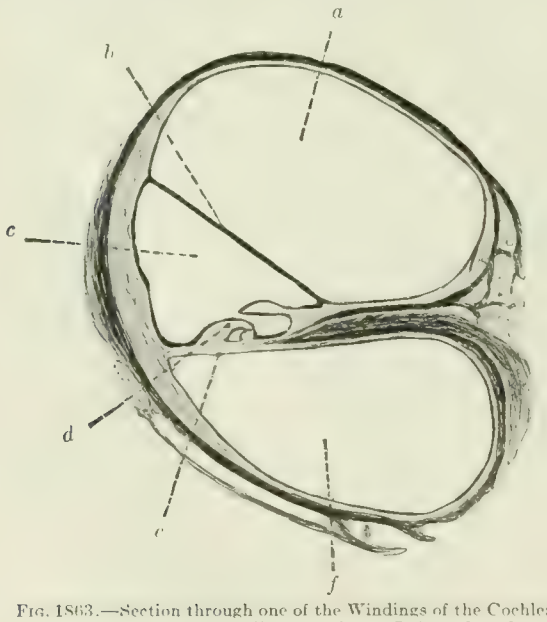


Fig. 1863.—Section through one of the Windings of the Cochlea. (Schematic.) *a*, Scala vestibuli; *b*, membrana Reissneri; *c*, ductus cochlearis; *d*, organ of Corti; *e*, membrana basilaris; *f*, scala tympani.

Theories and Tests.*—The internal ear is the end-organ of the eighth or auditory nerve. This nerve consists of two parts: The pars cochlearis and pars vestibularis. The cochlear nerve runs from a peripheral ganglion, the ganglion of Corti, situated in the lamina spiralis ossea. The vestibular nerve runs from the ganglion of Scarpa, situated within the depth of the internal auditory canal, and from there can be traced to the medulla oblongata. On one side it is connected with the cerebellum, on the other side with peripheral motor nerves, and the ganglion of the nerves supplying the muscles of the eye. This relation explains the important influence that irritation of the nervus vestibularis has upon many of the body muscles and especially the muscles of the eye.

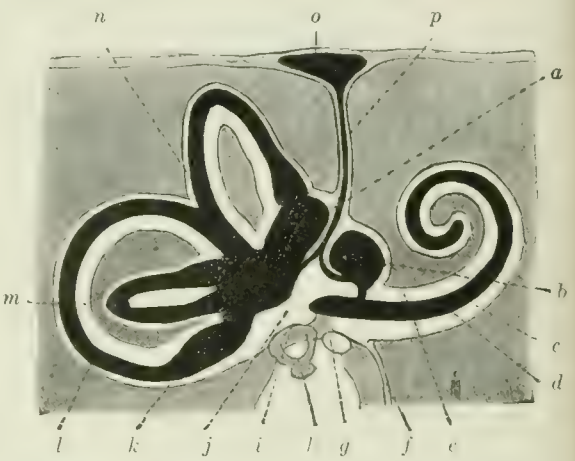


Fig. 1864.—The Membranous Labyrinth. (Schematic, after Lehmann.) *a*, Utriculus; *b*, sacculus; *c*, scala tympani; *d*, ductus cochlearis; *e*, scala vestibuli; *f*, canaliculus cochleæ; *g*, fenestra cochleæ; *h*, stapes; *i*, fenestra vestibuli; *j*, vestibule; *k*, ampulla; *l*, membranous posterior semicircular canal; *m*, osseous posterior semicircular canal; *n*, crus commune; *o*, saccus endolymphaticus; *p*, ductus endolymphaticus.

The cochlea constitutes the organ for the reception and differentiation of sound waves, thus has solely to do with hearing. The terminal filaments of the auditory nerve constitute the organ of Corti, which is situated on the membrana basilaris in the cochlea.

Opinion is unanimous that the sound waves are taken up by the hair cells of the organ of Corti and transmitted through the auditory nerve to the brain, thus recording sensations of sound.

Loss of parts of the tone scale occurs through degeneration of the different parts of the cochlea. Degeneration of the basal turn of the cochlea causes loss of hearing for tones of intermediate pitch and upper turn degeneration causes loss of hearing for tones of low pitch. The internal ear as a whole is designated as the sound-perceiving apparatus, although as stated the cochlea only has to do with hearing while the rest of the internal ear is chiefly concerned in controlling the equilibrium of the body.

Since the year 1825 various observations have been undertaken to demonstrate a certain connection between the internal ear and movements of the body and eyes. Ewald's experiment proved that there is a connection between the endolymph in any one of the semicircular canals and definite movements of the eyes and head. He made a fistulous opening in the right horizontal canal of a pigeon, one millimeter behind the ampulla. After sealing the canal behind the artificial opening he used a compression and rarefaction syringe. On compression of the syringe

* The following description of tests, etc., is taken largely from an article by the author on the labyrinth which appeared in the *Medical Record* of January 11, 1913.

and endolymph could move only toward ampulla, the other end being sealed. On aspiration, the endolymph could move only in the opposite direction, from ampulla to narrow sealed end.

On compression a steady, slow horizontal movement of head and eyes toward the left took place, which (we will shortly see) corresponds to a *horizontal nystagmus* toward the *right*. On aspiration a steady, slow horizontal movement of head and eyes toward the right took place, which corresponds to a *horizontal nystagmus* toward the *left*. This experiment demonstrated that the definite movements of the head and eyes depended upon the direction or course the endolymph took in any given canal.

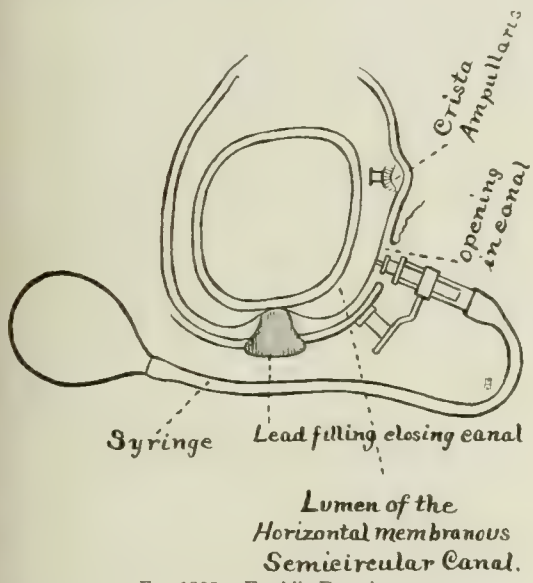


Fig. 1865.—Ewald's Experiment.

We have thus seen that Ewald, through his experiment, caused motion of the endolymph with its resulting nystagmus. But what is "nystagmus"? What methods (especially for human beings) can be brought into play to produce nystagmus?

*Nystagmus* (from the Greek word meaning to nod) is distinguished by rhythmical movements of the eyes of unequal velocity, and is, therefore, said to have two components, the quick in one direction and the slow in the other. The direction of the nystagmus is designated by the direction of the quick component, as this movement is most easily seen, though in reality the slow component is produced by the vestibular irritation. When the eyes are voluntarily directed toward the quick component it is characteristic of vestibular nystagmus that it increases in intensity and diminishes or ceases completely when the eyes are directed toward the slow component. The hair cells of the ampulla are pulled upon by the flow of the endolymph and this impulse is transmitted through the vestibular nerve to the medulla, and from there to the ganglion of the nerves supplying the muscles of the eye.

Methods for producing Nystagmus: (*a*) Turning Test; (*b*) Thermal: cold water irrigation, hot water irrigation; (*c*) Electrical—galvanic current.

*Vestibular Nystagmus Due to Turning.*—Under physiological conditions we assume that the endolymph in the semicircular canals is put in motion by turning a person and reflexly nystagmus takes place. In order to simplify matters we will assume a person is before us whose left labyrinth has been destroyed (disease). We are testing his right labyrinth. He is placed in a revolving chair with head and body erect. This position brings the horizontal semicircular canal into play so that it can be irritated.

Our subject is being turned to the right, in a direction from the tip of the nose toward the right ear, and we observe that during the turning he has nystagmus (primary) to the *right*. On sudden cessation of turning he has nystagmus (secondary or after nystagmus) to the *left*.

How do we explain this phenomenon? We will now assume that we are observing the right semicircular canal from above. When the turning commences the endolymph (and perilymph) move in the same direction in which the canal and hair cells are turning (to the right) (Fig. 1866); but through inertia

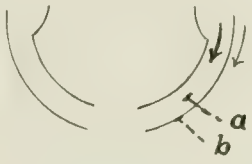


Fig. 1866.

Fig. 1867.

Fig. 1866.—Schematic. Right and left horizontal semicircular canal seen from above. Arrow shows direction of movement of (a) endolymph; (b) canal wall.

Fig. 1867.—Apparent Movement of Endolymph in Direction Opposite to that of the Turning.

*slower*, so that we get a direct displacement between the endolymph particles and the wall. That is from the canal to the ampulla (Fig. 1867).

From the experiment of Ewald we know that such a movement brings forth *nystagmus to the right.* On sudden cessation of turning, the canal remains stationary. The endolymph through its inertia keeps on moving to the right for a short time. We again get a direct displacement between the endolymph and wall; but now in the opposite direction. That is, from the ampulla to the canal (Fig. 1868).

We again come back to Ewald's experiment; a movement of the endolymph from the ampulla to the canal gives us *nystagmus to the left.* In the manner in which we especially irritated the horizontal semicircular canals, we can irritate the other canals.

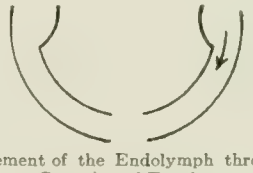

Fig. 1868.—Movement of the Endolymph through Inertia upon Cessation of Turning.

We must simply change the position of the person's head during the turning.

*How to Apply the Turning Test Practically.*—Take your regular revolving office chair. Seat your patient in the chair, the head thirty degrees forward, in order to bring the horizontal canal to a horizontal level in the plane of turning. Nystagmus is diminished through fixation of vision, therefore place a pair of opaque spectacles on the patient or have him shut his eyes or, still better, use on the patient Bartel's convex spectacles, through which you can observe his eyes all through the test; at the same time there is no fixation of vision.

As explained, the patient has nystagmus while turning (primary) and on sudden cessation of turning (secondary or after nystagmus). It is hard to observe nystagmus and turn a patient at the same time. For practical purposes we disregard the primary nystagmus and only observe the after nystagmus, from which we draw our conclusions. It is self-evident that in turning we irritate both labyrinths.

It is impossible to irritate one labyrinth when the other is functioning. Ewald's experiment gives us two definite facts:

(1.) A movement of endolymph from canal to ampulla in the right horizontal canal denotes nystagmus to the *right;* a movement of endolymph from ampulla to canal denotes nystagmus to the *left.* On the contrary, in the left horizontal semicircular

Fig. 1869.—Application of the Turning Test.

canal, the movement from canal to ampulla causes nystagmus to the *left,* and *vice versa.*

(2) The endolymph movement from canal to ampulla, in both right and left semicircular canals, causes a stronger irritation of the hair cells than the reverse.

After cessation we know that on turning to the right according to the law of physics, a movement takes place in the right horizontal canal from ampulla to canal and in the left from canal to ampulla (Fig. 1870).

Fig. 1870.—Movement of the Endolymph from the Ampulla on one Side and Toward the Ampulla on the Other.

The nystagmus produced by this movement will be in the same direction. When both canals have the same irritability the irritation from the left canal will be definitely stronger (movement from canal to ampulla) than the irritation from the right. Thus we can consider the after nystagmus to the left as measuring the irritability of the left semicircular canal. The reverse, the after nystagmus to the right, measures the irritability of the right semicircular canal. When we want to measure through the turning test the irritability of the right semicircular canal, we must turn the patient to the left, in a direction from the tip of the nose toward the left ear. On the contrary, in measuring the irritability of the left semicircular canal we must turn the patient to the right, in a direction from the tip of the nose toward the right ear. In order to induce maximum irritability of the labyrinths, Bárány found that we must make ten turnings in about twenty seconds.

Florens discovered the law that each semicircular canal produces nystagmus in its own plane. It simply depends on the position of the head. We irritate the different canals according to the relation of the canals to the plane of turning. This is brought about through the various positions in which the head is placed. The horizontal canals are best irritated when the head is thirty degrees forward. It is hardly possible to irritate one set of canals alone; usually another set is irritated at the same time, moving the head backward or forward, causing an irritation of the superior canals as well as the horizontal.

We consequently get two kinds of nystagmus, *horizontal* and *rotary,* from the superior canals.

If one is turned with head ninety degrees to the shoulder the superior vertical canal is stimulated. The resulting nystagmus is *vertical* (with relation to the head). If one is turned with head ninety degrees forward, the posterior canal is stimulated. The resulting nystagmus is rotary.

Now, to come back to our patient or subject. Practically it is always necessary to turn in both directions in order to have a ratio of comparison. We have turned him ten times to the right, head thirty degrees forward. On sudden cessation of turning we get horizontal nystagmus to the left, which is pronounced and lasts a certain length of time. That, we assume, is the measure of irritability of his left semicircular canal. We rest a few minutes to allow the reaction of the test to pass and then turn him to the left. We get after nystagmus to the right, pronounced and lasting about the same time. We consequently assume that both canals or labyrinths are equal in regard to irritation. They are normal.

We test a second subject. Turning him to the right, he has after nystagmus, pronounced and lasting. On turning him to the left, he has after nystagmus to the right; it is weak and lasts only about half the length of time. We naturally conclude that there must be some condition present which causes an interference with the normal irritability of his right horizontal semicircular canal (labyrinthine disease). This is the basis of the turning test. After some practice, one tells instinctively the difference in irritability between the two labyrinths.

In general the test is not very reliable, for we are irritating both labyrinths at the same time, and there is no way of telling the amount of influence one labyrinth has on the other.

This brings us to the caloric test, which is superior, because each labyrinth is tested separately.

*Physiological Caloric Nystagmus* (Bárány).—This is made with (*a*) cold water irrigation, or (*b*) hot water irrigation.

We place our subject in a chair, with head and body erect. This is the definite position for irritation of the right horizontal canal. Irrigate his right ear with cold water. We notice shortly nystagmus to the left (opposite side of irrigation).

What has occurred? The horizontal canal is so placed that when the head is erect so that the zygomatic process is horizontal, the horizontal semicircular canal is not really horizontal. It forms an angle of thirty degrees with the lower surface of the horizontal plane. Now, according to physical law, when various parts of a definite fluid do not possess a general temperature, usually a movement takes

place in the fluid. This movement causes changes in position of the fluid. The heaviest fluid, which is in general the coldest, sinks below. We have the same condition in the labyrinth. When the endo- and perilymph are cooled, a movement takes place toward

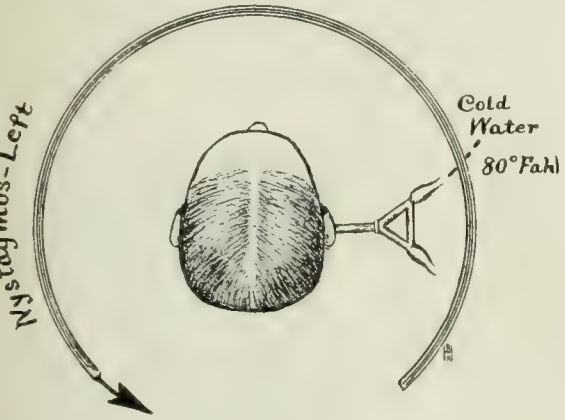


Fig. 1871.—Bàràny Test.

the lower level; in this instance from ampulla to canal (Fig. 1872).

On the other hand, when heated, the movement takes place from a lower to a higher level, *i.e.* from canal to ampulla (Fig. 1874). This movement of the

Fig. 1872.—Movement of the Endolymph on Cooling.

endolymph causes a repetition of the Ewald experiment. Accordingly, when we irrigate with cold water and a movement takes place from ampulla to canal we get nystagmus to the side opposite the irrigation.

On the contrary, irrigating with warm water

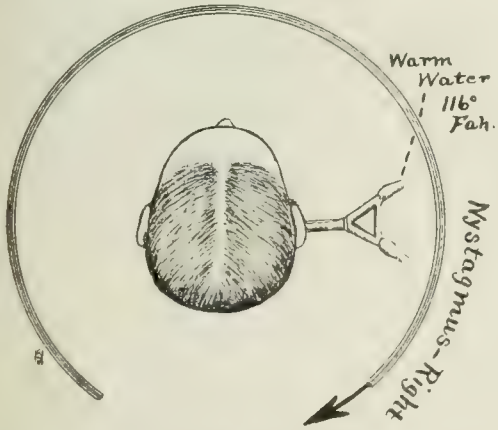


Fig. 1873.—Bàràny Test.

causes a movement from canal to ampulla, and the resulting nystagmus is to the right or side of irrigation.

We must credit Brünings for his ingenuity in putting the application of this test on a standard practical basis. Working on the theory that the canal is a ring in which fluid (endolymph) is moving, he showed through a series of experiments that the most favorable condition for the movement of endolymph to take place in the horizontal canal was when the canal was in a vertical position. This was designated by him as the optimum position (head sixty degrees backward). The contrary, where the canal was horizontal, head thirty degrees forward, he designated

Fig. 1874.—Movement of the Endolymph when Warmed

as the pessimum position, it being unfavorable for endolymph movement. Caloric nystagmus, due to irritation of the horizontal semicircular canal, attains its maximum in the optimum position, and is almost or completely extinct in the pessimum position.

To come back to our patient. He is seated, head sixty degrees backward and right ear is being irrigated (with cold water). Doing the test roughly, we bend the subject's head backward and guess when it is about sixty degrees. We take a Politzer bag or a douche bag, with rubber tubing attached and pointed

Fig. 1875.—Optimum Position for the Caloric Test.

or olive tip at end of the tubing, and irrigate the ear until nystagmus takes place. Bárány advised 80° F. when using cold water and 116° F. when using warm water. All this was a matter of guesswork. The strongest factor in judging the irritability or non-irritability of a labyrinth was personal and practical experience through continued observation. There was no standard to go by. All this is done away with

through the two splendid instruments invented by Brünings: The *otogoniometer* and *otocalorimeter.*

*The Otogoniometer.*—The principle of the otogoniometer is to show the direction of the horizontal semicircular canal and to place the eyes in a lateral position without causing interference with convergence and accommodation. It consists of a self-retaining metal band, which fits around the head. There is also a fixed semicircular scale (*a*)

Fig. 1876. Positions for the Caloric Test.

and a movable scale (*b*), to which is attached a pointer (*c*). The instrument is fastened on the patient's head so that when the pointer is horizontal it is in a direct line with the zygomatic process. The pointer is then moved thirty degrees upward according to the attached scale, so that the pointer and an imaginary line through the central axis of the horizontal canal unite. The head is then bent backward until the pointer is vertical. The horizontal canal is then in a vertical position, or after Brünings in the optimum position. There is a second movable pointer (*d*) which glides in a right and left direction on the fixed semicircular scale. It has a small mirror attached to the extreme end. The mirror is set so that the person tested sees the reflection of some object in the room. When the rod is placed on the scale marked fifty degrees the line of vision is correct. Fixation of vision takes place without accommodation and convergence. When fixation occurs with accommodation and convergence it has a disturbing influence on nystagmus.

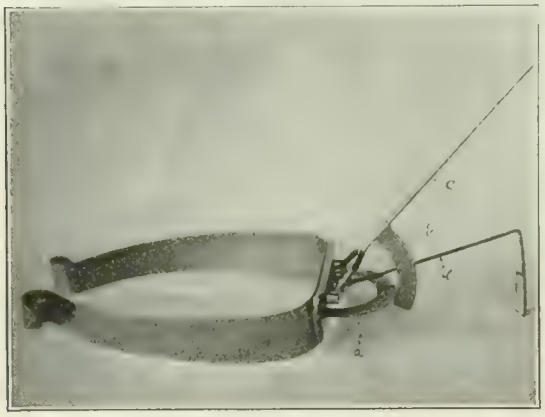

Fig. 1877. The Otogoniometer.

*The Otocalorimeter.*—The otocalorimeter is an instrument that allows us in a practical way to measure the irritability of the labyrinth through the definite quantity of water used when irrigating. It consists of two glass receptacles, a large one above with thermometer attachment, for holding a quantity of water of a definite temperature; and a small one below, which serves to measure the quantity of water used until the instant nystagmus sets in (Fig. 1878).

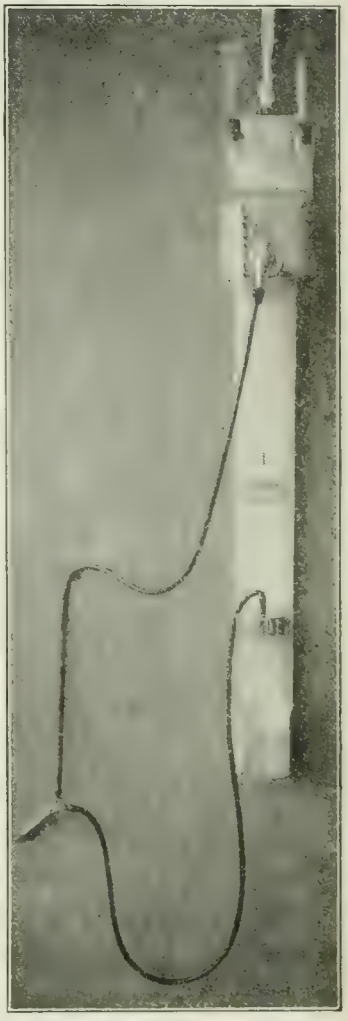

Fig. 1878.—The Otocalorimeter.

One of the important features of the otocalorimeter is the ear piece, because it gives us regularity in introduction and excludes trauma. It consists of a double current metal olive, which is connected to both glasses with two rubber tubes. Water leaves the upper glass, goes to the ear, then flows into the measure glass below. There are three scales on the measure glass (Fig. 1879). The first designates the quantity of water used, the second and third designate directly the irritability of the labyrinth under examination, measured through the quantity of water used until we get nystagmus. This irritability is compared to a normal standard which corresponds with an assumed normal labyrinth that gives nystagmus after using 70 c.c. of water, temperature 27° C. (80.6° F.) So that figures below the assumed normal standard (1 in Fig. 1878) signify exaggerated irritability; above, diminished irritability.

When the irritability of the labyrinth is not greatly changed Brünings recommends the use of water 27° C. (80.6° F.) as cold irrigation. When irritability is markedly diminished he employs water of 20° C. (68° F.). In using warm water he recommends a temperature of 47° C. (116.5° F.). The object is to create a similar difference in number of degrees between the body temperature and the temperature of the irrigating fluid. The body temperature being 37° C. (98.5° F.), cold water used should be 27° C. (80.6° F.) and warm water 47° C. (116.5° F.); a difference of 10° C. (18° F.) above and below body temperature. To *recapitulate:* Take our patient, attach the otogoniometer, move the scale thirty degrees above the fixed scale,

then move the head backward so that the pointer is vertical. Set the pointer with mirror attached laterally; to the opposite side when irrigating with cold water and to the same side when using warm water. See that the patient regards a distant object in the mirror (Fig. 1880). Irrigate with the selected cold or warm water until nystagmus sets in. The amount of water used gives us the measure of irritability of the tested horizontal semicircular canal.

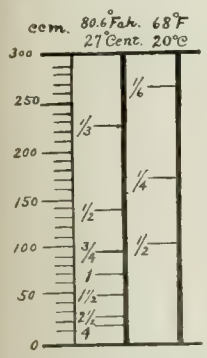


Fig. 1879.—The Scales on the Measure Glass of the Otocalorimeter (enlarged).

*Galvanic Nystagmus.*—We place an electrode (current 10-24 ma.) before the tragus of the right ear of a person. The other electrode he holds or it is placed elsewhere on the body. We find that if the electrode in front of the ear is the anode (+) he will get nystagmus to the left. If we replace the anode (+) by the cathode (−) we get nystagmus to the right.

Some authorities assume that the galvanic electric current directly stimulates simultaneously the terminal filaments of the vestibular nerve and the nerve itself. According to other authorities (Brünings) the galvanic electric current produces a similar movement of the endolymph (cataphoresis) to that which the turning or irrigation induces.

Besides nystagmus, in which the eye muscles are involved, there are other muscles that are affected through irritation of the labyrinth with its resulting nystagmus. For example:

*The Bárány Indication Test.*—When a person has nystagmus and is told to point at a certain object, he will point either to the right or to the left side of the object, depending on his nystagmus. If he has nystagmus to the right, he will point to the left of the object, and *vice versa*. In a differential diagnosis between certain cerebellar and vestibular conditions, the indication test is an important factor. Another one of the principal symptoms resulting from irritation of the labyrinth is vertigo.

*Vertigo*, used synonymously with dizziness, is a sensation of movement a person experiences, whether he is really moving or not; this may be accompanied by reeling, and surrounding objects appear to be moving in some definite direction when in reality they are at rest. Vertigo in general may occur with or without any recognizable nystagmus. Labyrinthine vertigo is almost always accompanied by nystagmus.

We thus possess a means by which we can artificially produce vertigo. When this vertigo reaches a certain degree of intensity it is associated with objective symptoms. The patient is uncertain in gait and posture; he may even fall. When he falls through vertigo due to disease of the labyrinth, the direction in which he falls always depends on the direction of the nystagmus. Thus, horizontal nystagmus to the right is associated with falling to the left and *vice versa*. In horizontal nystagmus to the left with the head turned ninety degrees to the shoulder, there is falling to the front. With horizontal nystagmus to the left the head being turned to the right shoulder ninety degrees there is falling backward.

The above facts are of vast importance when we attempt to make a differential diagnosis between labyrinthine disease and cerebellar disease. In cerebellar disease the direction that one falls is not regularly influenced by the direction of the nystagmus.

The objective symptom of vertigo, the tendency to fall, can be made more evident through the Romberg phenomenon.

*The Romberg experiment* consists in having a person stand with eyes closed and feet together. When there is no disturbance in static function the person will keep his equilibrium. When there is a disturbance he will have a tendency or fall to one side. The position in which we keep our body is due to three factors—tactile sense, optic sense, and vestibular static function.

In order to sustain equilibrium at least *two* of these three factors are necessary. Through simple closure of the eyes, one factor is eliminated. When the tactile (tabes dorsalis) or vestibular sense (labyrinthine disease) is destroyed, equilibrium is not sustained and the Romberg sign is positive.

Fig. 1880.—Practical Application of the Caloric Test.

*Turning Sensation.*—The subjective turning sensation that the patient experiences is in relation to the direction of the nystagmus. Nystagmus from left to right gives the illusion that the surroundings are turning from left to right, and *vice versa*.

*Vascular and Gastric Disturbances.*—Occasionally we get pallor, nausea, vomiting, etc., with nystagmus. These accessory symptoms are in general not very pronounced in cases of experimental nystagmus of a normal person. They may reach a high degree of intensity in some nervous conditions, especially neurasthenia and traumatic neuroses.

*The Comparative Value of the Different Labyrinthine Tests.*—The turning test is far easier to put in execution than the other tests, but it has two disadvantages. It is impossible to test each labyrinth separately and in cases of severe sickness it is really not permissible.

The galvanic test has the same disadvantages. Definitely each labyrinth cannot be tested separately and occasionally, especially in nervous individuals, very disagreeable secondary effects follow.

The caloric test has one immense advantage that

surpasses all its disadvantages. We are able to test each labyrinth separately. It is understood, that in measuring the excitability, as for example with Brünings' system, we must take into account local conditions, which influence the conduction of the temperature, viz., stenosis of the external auditory meatus, polyps, inflammation of the middle ear, the condition of the drum membrane, presence of secretion, of cholesteatoma, etc. Again it is not always possible to carry out the test as advised with water, as in cases of dry perforation. In such cases, water is supplanted by paraffin or air (hot or cold). Notwithstanding these disadvantages, the caloric test at present is the major test.

Pathological Conditions of the Sound-perceiving Apparatus.—In pathological conditions of the sound-perceiving apparatus a definite tone picture is present.

The voice is negative. Words of low pitch are heard less distinctly than words of high pitch or *vice versa*.

Air conduction as obtained by tuning forks (Cc c c c c), the Galton whistle, and monochord show that high pitch tones are heard worse than low pitch tones. The upper tone register is lowered.

A c tuning fork placed in contact with the vertex midway between the ears is lateralized to the non-affected ear. (Weber's test.) It may however not be lateralized.

Bone conduction (Schwabach test) is rarely normal, almost always shortened.

The Rinne test is positive; that is, tone perception through the air exceeds tone perception through the bone.

To determine definitely the part of the sound-perceiving apparatus affected is not possible through functional hearing tests.

A central deafness that has its seat in the cortex of the brain may give the same results as a pathological condition of the auditory nerve, the spiral ganglion of the cochlea, or the organ of Corti; although recent pathologico-anatomical experiments have given definite differences in such conditions.

*Etiology and Symptomatology.*—Atrophy of the auditory nerve may be due to tabes, syphilis, diabetes, progressive paralysis, etc.

Tumors (sarcoma, fibroma, and neuroma) may invade the internal auditory canal exerting pressure and cause atrophy. Exostoses may produce like results.

The result of toxic conditions produced by quinine, salicylate preparations, nicotine, and alcohol, also typhoid fever, scarlet fever, and mumps have caused pathological conditions of the spiral ganglion of the cochlea. The organ of Corti has been primarily affected through occupation noises from various trades.

In diseased conditions of long standing the different parts above enumerated, organ of Corti, spiral ganglion of the cochlea, and auditory nerve, are finally affected together so that pathologically, anatomically and clinically it is impossible to differentiate the part affected. As shown, the involvement of the internal ear through various diseases is definite.

Hemorrhages in the labyrinth have occurred in cases of leukemia, pernicious anemia, purpura hæmorrhagica, etc. The blood which contains a number of lymphocytes causes compression, and a degeneration of the nerve, the ganglion cells, and organ of Corti results.

Hemorrhage into the labyrinth is regarded by some as the cause of caisson disease. Men working in compressed air get a sort of apoplectic seizure, during which they develop the Ménière symptom-complex (disturbance of hearing, vertigo, tinnitus, nausea, and vomiting). Gas emboli and extravasations of blood are assumed to plug the labyrinthine capillaries.

Acoustic neuritis may be due to any condition causing a neuritis in other parts of the body. The nervus cochlearis is almost always involved.

*Diagnosis.*—An absolute diagnosis is not always possible, but from the etiology and symptoms and through a process of elimination the diagnosis can usually be made. Noting the causative factors, nerve deafness may be due to poison from various drugs—quinine, the salicylates, tobacco, alcohol, lead, phosphorus, etc.

Through bacterial toxins in the blood such conditions as typhoid, typhus, tuberculosis, measles, scarlet fever, diphtheria, and mumps cause nerve deafness. Diabetes, syphilis, and the rheumatic diathesis are very important as cases caused by constitutional conditions. A primary atrophy of the acoustic nerve is found in old age and in those with premature arteriosclerosis.

In tabes a progressive deafness due to nerve atrophy is sometimes the first symptom noted of the disease. A thorough physical examination of all cases of hardness of hearing greatly aids in making a diagnosis.

Of all the conditions of the labyrinth already mentioned, the ones which interest us most are the inflammations. How are they classified and how do they occur?

Labyrinthitis.—The inflammatory conditions of the labyrinth (labyrinthitis) may be classified according to extension or according to the nature of the inflammatory conditions. According to the degree of extension there exists a circumscribed labyrinthitis, in which the inflammation is localized in one part of the labyrinth; or there may be a general labyrinthitis in which the entire labyrinth is involved. According to the kind of inflammation, we have on the one hand a serous labyrinthitis, and on the other a plastic labyrinthitis, which is only a form of healing process of these exudative inflammations.

*Etiology and Pathology.*—A primary spontaneous labyrinthitis, until the present, has not been positively observed. Those cases which have been assumed to be such in all probability were and are the results of cured meningitis. We have to assume, with the exception of direct infection of the labyrinth, that all inflammatory conditions of the labyrinth are secondary inflammations, the sequels to other morbid processes in the system. The conveyance of the morbid agent can be effected (1) directly, (2) through vascular channels, (3) through extension by continuity. Besides a labyrinthitis the consequence of an accidental traumatic condition (fracture of the base) the *first group* is the most important of the forms of operative labyrinthitis. These may occur through direct infection; or the operative procedure may cause a latent inflammatory condition existing in the labyrinth to become acute; or finally an operation may cause an extension of a middle-ear process to the labyrinth.

Under the *second group* (vascular channels) we note that morbid agents can be transported by way of arteries from distant parts of the system to the labyrinth and produce a metastatic labyrinthitis as in typhoid fever. Cases of labyrinthitis occurring through the venous system (phlebitis) are very rare.

The *third group* is that in which extension occurs by continuity. The labyrinth itself forms part of a system of cavities. The cavity of the middle ear lies on one side, and the encephalic cavity on the other. According to the source of infection, Goerke designates the condition as either a tympanic or an encephalic labyrinthitis. There are several natural ways through which an infection can pass from the encephalic cavity to the labyrinth. Among these may be mentioned the lymphatic spaces in the sheath of the auditory nerve, the ductus vestibularis (endolymphaticus), and especially the aquæductus cochleæ. Between the labyrinth and the series of

spaces (tympanic cavity, Eustachian tube, mastoid cells) there does not exist, with the exception of the vascular system (which can hardly be taken into consideration) any natural communication.

A propagation of infection from the series of spaces into the labyrinth can occur only after rupture of the labyrinth capsule. These penetrations into the labyrinth occur usually in the following order: the fenestræ, promontorium, and horizontal semicircular canal.

*Symptoms.*—In order to appreciate fully the recognized forms of labyrinthitis (circumscribed and diffuse), the following clinical picture of an acute and latent destruction of one labyrinth is given.

*Acute Exclusion of the Function of One Labyrinth.*—There is a train of general symptoms that goes with all cases of acute exclusion of the labyrinth regardless of cause and form. The condition may be due to acute purulent labyrinthitis, hemorrhage in the labyrinth the result of arteriosclerosis, leukemia, syphilis, fracture of the base of the skull, etc. Following the injury we get spontaneous symptoms, subjective and objective, such as nausea, vomiting, vertigo (with disturbance in equilibrium), and nystagmus, rotary and horizontal to the sound side. The patient assumes a characteristic position in bed. He lies on his sound side, which is always the side to which he has his spontaneous nystagmus (quick component). We know that vestibular nystagmus is diminished by looking in the direction of the slow component and increased by looking in that of the quick component. From the position assumed in bed the eyes are directed toward the slow component and all annoying symptoms are relieved. The patient finds lying more comfortable, for as soon as he tries to sit up, nausea, vomiting, severe vertigo, with apparent movement of surrounding objects, set in. A sensation of turning the body and inability to walk are often complained of.

A patient with the above spontaneous symptoms reacts in a certain measure when put through the different tests and we get a train of induced symptoms. The turning test in a case, where the right labyrinth is excluded, will give stronger after-nystagmus to the sound (left) side on turning to the right than to the diseased side when turned to the left. The nystagmus to the diseased side usually lasts about fifteen to twenty seconds. The nystagmus to the sound side about fifteen to forty seconds.

The caloric reaction shows that the diseased labyrinth responds slightly or not at all to the irritation of the test. We derive the same results from the galvanic test. In case the condition in the labyrinth is such that there is an erosion of the bony wall (a fistula), we can (when the labyrinth is still capable of functioning) often induce a new phenomenon, viz.,

*The Fistula Symptom.*—Through compression and rarefaction of the air in the external auditory canal and tympanic cavity we get nystagmus. Compression and aspiration of the membranous canal through the fistula in the bone causes active nystagmus of some seconds' duration. The direction of the movement differs in different cases. Compression is always opposite to that of aspiration.

To make a practical application of the fistula test an olive shaped tip fitted into a Politzer bag is inserted tightly in the external auditory meatus of the diseased (say the right) ear. While the patient looks directly forward, sudden strong pressure is made on the bulb. When a fistula is present and the labyrinth is still functionating nystagmus will occur in most cases to the right and seldom to the left side, and by aspiration in most cases to the left and seldom to the right side.

As stated, the above enumerated symptoms come on suddenly. They can last a certain length of time and gradually abate. In rare cases, in addition to the labyrinth affection we get cerebral complications.

The opposite to this very acute form of labyrinth exclusion is a

*Latent Exclusion or Destruction of the Labyrinth.*—We will assume that one side is affected. The patient complains of attacks of vertigo, which may come on suddenly, and last from a few seconds to a few minutes. These attacks may be or may not be associated with an external cause. The external causes are rising or inclining the head backward or to the diseased side, rapid movements of the head, stooping forward, going from a hot to a cold room, or *vice versa*. The patient may quietly sit or sleep. An attack may occur while walking. There may be some nausea, but vomiting, as a rule, is not present. In general, when the eyes are in the extreme lateral position (either right or left), there occurs a weak, spontaneous rotary or horizontal rotary nystagmus, which is not influenced by movements of the head.

Caloric test of the diseased side is negative, no reaction. Caloric test of the sound side gives distinct rotary nystagmus. Galvanic test of the diseased side for both anode and cathode is negative, or nearly so. Aspiration and compression tests are negative. The turning test, to the diseased side, head erect, produces horizontal after-nystagmus to the sound side of about thirty seconds' duration. Turning to the sound side produces horizontal after-nystagmus of about fifteen seconds' duration. Usually the nystagmus due to the diseased side lasts about half the length of time of the sound side. There are no disturbances in equilibrium. The patient always gives some history of a running ear, acute or chronic, and of impairment of hearing. The cochlea is usually involved.

To come back to our classification we will now assume we have a patient with a

*Circumscribed Labyrinthitis.*—The patient complains of attacks of vertigo as his main trouble. On going into his history you find he has an acute or chronic middle ear suppuration of some standing. There is impairment of hearing or complete deafness on the affected side and occasionally tinnitus. His vertigo occurs with or without an external cause; practically the same as that described under latent labyrinthitis. The attacks may last from several seconds to several hours. They are accompanied by nausea, disturbances in equilibrium, and sometimes vomiting. In the interval between attacks the patient feels perfectly well. On examination during an attack one finds nystagmus, usually to the sound side. Occasionally the nystagmus is also seen to the diseased side. The caloric test and the turning test give an almost normal reaction. In these cases the fistula phenomenon is of prime importance. It is a great diagnostic point in differentiation between a diffuse and a circumscribed labyrinthitis. So long as the fistula symptom is present we can exclude a diffuse labyrinthitis.

A circumscribed labyrinthitis usually commences as an acute or chronic suppurative otitis media, then an erosion of the labyrinthine wall (fistula) occurs, with the resulting circumscribed labyrinthitis.

*Diffuse Labyrinthitis* (Serous, Purulent).—In our anatomical classification we mentioned a serous and a purulent labyrinthitis. The difference is not only of an anatomical pathological significance, but is of great clinical value, especially from a prognostic and therapeutic standpoint.

The serous form almost always abates, while the purulent form has a worse prognosis. Operative interference is not necessary in the serous form, while in the purulent form it usually is. In both forms we get the general symptoms that have been described under acute destruction of the labyrinth. The symptoms are much stronger in the purulent form than in the serous form.

The presence of fever and complete loss of function of the labyrinth (total deafness, etc.) are almost

positive signs that we are dealing with a purulent labyrinthitis. In the serous form we can also have almost complete loss of the labyrinth function, but in general the function is present to a certain extent.

*Outcome of the Several Forms of Labyrinthitis.*—The *circumscribed* form may continue to exist as such. It may also abate or through some condition become a general labyrinthitis. We must not forget to consider that there is a great tendency for inflammations of the labyrinth to become encapsulated.

The *serous labyrinthitis* may subside completely with conservation of function, or, on the other hand, pass into a plastic or purulent form.

The *purulent form* can also abate, but only after partial or complete loss of function, and change into the plastic form. When it does not abate, it progresses and causes cerebral complications. The channel of propagation can occur through the natural existing communications (ductus endolymphaticus, ductus perilymphaticus, meatus internus, vascular system) or through artificial ways created by the morbid process.

*Diagnosis.*—Making a résumé of all that has been said of labyrinth disturbances, we notice two symptoms stand out prominently—vertigo and nystagmus. There are, however, many conditions that give vertigo and nystagmus besides labyrinthine affections, and in making our diagnosis these conditions must always be thought of and taken into consideration. The history of each case is significant and of prime importance. A thorough examination of the ear and the application of the various tests almost always show if there is any connection between the spontaneous attacks of vertigo or vertigo and nystagmus, of which the patient complains, and the labyrinth.

Practically nystagmus always exists when the vertigo is of labyrinthine origin. The presence or absence of fever must be carefully looked into. Patients suffering from neurasthenia, arteriosclerosis, menopause, have spontaneous attacks of vertigo with or without nystagmus. Those suffering from toxic influences, gastrointestinal trouble, smokers and drinkers have spontaneous attacks; almost all persons who have received an injury about the *head* complain of vertigo. These cases are of medicolegal interest. The history of the cases, the local ear condition, and the response to the various tests lead us to the correct diagnosis.

In meningitis we very often get nystagmus which is of intracranial origin, not vestibular. We base our diagnosis on the general meningeal symptoms present. Temperature, severe headache, vomiting, severe stiff neck, hyperesthesia, lumbar puncture, cloudy fluid, abducens-paralysis, the Babinski, Koenig, choked disc signs, etc.

The differential diagnosis between some cerebellar affections (tumor or abscess) and labyrinthine conditions is difficult. In both we usually get vertigo and nystagmus. The following table may aid in differentiation:

| *Cerebellar Disease.* | *Labyrinthine Disease.* |
|---|---|
| Nystagmus: Directed to diseased or sound side or both; to diseased side somewhat stronger. General tendency to grow stronger or may remain the same. Usually rotary. | Nystagmus: Directed to sound side. Tendency to diminish and cease; usually horizontal; may be both. |
| Labyrinth usually responds to tests. | Response to tests diminished or lost. |
| Choked disc usually present. | Choked disc absent. |
| Patient usually lies on diseased side. | Patient lies on sound side. |
| Placing patient on sound side increases his vertigo, vomiting, and pulse. | Placing patient on diseased side increases his vertigo, vomiting, and pulse. |
| Romberg Phenomenon: Eyes shut and feet together, patient sways or falls to either side, not depending on nystagmus or position of head. | Romberg Phenomenon: Eyes shut and feet together, falls or sways to diseased side, or depending on direction of nystagmus or position of head. |

It is of practical value to make this last comparison somewhat clearer. We have said that there exists in a majority of cases a definite connection between the direction in which a patient has a tendency to fall and the direction of his nystagmus when due to labyrinth disease, namely, nystagmus to the right, tendency to fall to the left and *vice versa.* In cerebellar affections (especially conditions of the vermis) the above definite connection does not exist. When we produce nystagmus to the right, instead of falling to the left, as in vestibular disease, the patient may fall to the right or in some other indefinite direction. There is absolutely no connection between the direction of falling and the nystagmus.

Lately Bárány brought out the "indication test," a test that is of vast importance in a differential diagnosis between labyrinth and cerebellar disease. Normally, when a person is shown an object, then told to shut his eyes and point with index-finger at that object, he will do so correctly (Graefe's test). When we induce nystagmus and no pathological condition is present a person will point to the right or left of the object, depending on his nystagmus. When a person has cerebellar disease, with or without having nystagmus, he will point spontaneously, not depending on nystagmus, to the side of the object. Where we induce nystagmus in such a person through any of our tests, we find that his pointing is hardly or not at all influenced. He continues pointing, as he did previously, spontaneously, almost or completely to one side of the object.

*Treatment.*—With the exceptions of the inflammations, the treatment of all conditions of the internal ear is directed mainly to combating the cause and thus checking further damage.

The various neuroses, reflex and otherwise, cases of anemia, hyperemia, and hemorrhages in the labyrinth, are treated the way such conditions are treated elsewhere in the body, but with less satisfactory results. Drugs in use are few.

In hemorrhage pilocarpine has been used extensively, beginning with gr. $\frac{1}{8}$ either by mouth or hypodermic injection three times daily, the dose being increased until the physiological effect is produced.

The different forms of massage about the ear sometimes produce soothing results in a certain class of patients.

In general no matter what is done, relief attained if any, is usually temporary.

In the inflammatory conditions, besides the cause, we carefully treat the diseased focus according to general surgical principles. The essential is the removal of all diseased tissue and the establishment of free drainage.

*An acute labyrinthitis* following an acute otitis media should not be operated upon. Rest and local treatment of the ear may suffice. If operated upon, free exposure of the antrum mastoideum in the usual way is sufficient.

*A circumscribed labyrinthitis* following an acute or chronic suppurative otitis media should be treated conservatively (rest, etc.). The local ear condition should be treated in the usual manner. If after sufficient observation operative interference is found

necessary, one should do a radical mastoid operation and examine carefully the horizontal semicircular canal and promontory for fistula, caries, and granulations. If the labyrinthine symptoms abate, the conservative treatment of the labyrinth was correct. If they continue or become aggravated, a labyrinth operation, partial or complete, is indicated.

A middle ear condition may cause a *diffused labyrinthitis* primarily, or a circumscribed labyrinthitis can become diffused, especially following a radical mastoid operation. If the condition is a diffused serous labyrinthitis, it is not grave and operative interference is not necessary.

If the condition is a *diffused purulent labyrinthitis*, it is dangerous. Very often complications set in—meningitis or brain abscess. As soon as a diagnosis is made one should operate, if possible before complications set in. There are several methods of doing a partial or complete labyrinth operation:

1. The carious portion of the horizontal semicircular canal may be removed with a sharp curette.
2. The canal and promontory may be opened, curetted, and drained, either laterally or medially. By laterally, we mean opening the horizontal canal and proceeding upward to the vestibulum, which is also opened. Medially, we open the vestibulum by way of the fenestræ and proceed to the horizontal canal.
3. The canal, promontory, and spindle of the cochlea (if found carious) should be removed.
4. The posterior portion of the pyramid up to the internal auditory meatus is removed. This destroys the posterior and horizontal semicircular canals. Then the promontory is removed.

In doing the labyrinth operation there is always danger of injury to the facial nerve and a paralysis may result. Bourguet's facial protector is recommended by some authorities.

James S. Greene.

**Ear: Diseases of the Auricle.**—Cutaneous Diseases.—Cutaneous diseases of the auricle differ in no essential particular from diseases of the skin involving other parts of the body, and are of interest to the otologist only because, in their localization at this point, he may be called upon to treat the lesion, and also because of the fact that some of these cutaneous diseases may extend to the epithelial lining of the external auditory canal, and give rise to deafness, or, in neglected cases, may extend into the deeper structures of the ear and give rise to grave complications.

*Acne.*—Acne of the auricle is rare and has no special characteristics to distinguish it from acne elsewhere.

*Ecthyma.*—Ecthyma appears in the form of large, single pustules with an infiltrated, hard, and elevated base, and flattened in the center. They soon become covered by a dark crust which, after falling off, generally leaves a crater-like, round ulcer with sharp, slightly elevated margins; the surface of the ulcer is covered with a greenish-yellow scab under which the pus wells up on light pressure. Through the confluence of several ulcers, and the extension of the disease into the deep tissues, there may develop an extensive inflammation of the skin and cartilage. Barnick describes a case in which, in the edges of the ulcer, were many bleeding points ("ecthyma hæmorrhagicum"), as also an endarteritis of the blood-vessels of the skin. The base of the ulcer showed everywhere granulation tissue. In the microscopical preparations staphylococci and streptococci were found.

*Eczema.*—Eczema may occur in all parts of the external ear. It may be confined to the auricle, or the canal may also be involved; in some cases the affection may even extend to the dermal layer of the drum membrane. Eczema may occur idiopathically in the ear or it may extend from an eczema of the face or head. (The reader is referred, for further information in regard to eczema of the auricle, to the article *Ear, Diseases of the External Auditory Canal.*)

*Herpes.*—Herpes of the auricle or herpes oticus is rare, and is due, according to the belief of Ramsay Hunt, to an herpetic inflammation (posterior poliomyelitis) of the geniculate ganglion situated in the internal auditory canal at the entrance of the Fallopian aqueduct. The inflammation may extend to the nerve roots and give rise to a facial palsy, or the auditory nerve may become involved with symptoms of Ménière's disease in marked cases, or with some deafness and tinnitus in those less marked. The outbreaks of herpes are nearly always accompanied by neuralgic pains on the affected side of the head and in the ear, and at times even the mastoid process is painful. This symptom of pain in the mastoid was so marked in one case reported that the wrong diagnosis of mastoiditis was made, and the true state of affairs was not discovered until a short time before the proposed operation was about to be undertaken.

As to the appearance presented by the disease when it involves the auricle, the skin of the auricle is swollen and red for a few days before the appearance of the vesicles and the external auditory canal often becomes occluded. About the eighth day desiccation takes place and the disease except for the scars is generally over in two weeks. Only exceptionally does the process assume a gangrenous character. Recurrences are not uncommon in simple herpes.

The treatment consists in the administration of narcotics when there is severe pain; in the reduction of temperature by suitable measures; in the use of compresses of bichloride of mercury (1–3,000 or 1–4,000) during the purulent stage; later boric acid, subgallate of bismuth, or xeroform dusted on the parts, and, if ulcers have formed, cauterization with silver nitrate.

*Impetigo Contagiosa.*—Impetigo contagiosa appears as a small red spot which soon develops into a pustule that may reach the size of a large pea. In course of time this breaks down and a crust is formed. By contamination with the pus new foci may develop, and so there may be found at one and the same time lesions in all the various stages. The disease assumes the character of an infection and is mostly epidemic. The neighboring lymph glands are swollen. Children are the chief sufferers from this affection, but adults are not always exempt.

The treatment consists in bathing with green soap and then applying zinc ointment or an ointment of bismuth subgallate.

*Pemphigus.*—Pemphigus of the ear is not observed very frequently as an independent affection; it is more often seen as a part of the same general affection of the skin.

After a prodromal stage of lassitude and weariness, there follow fever and an eruption of discrete, slightly elevated, red spots on which develop bullæ distended with serum or blood. These may be of varying sizes, from the dimensions of a grape-seed to that of a hazelnut. The bullæ burst and leave a red surface which is quickly covered over with new skin. Thus the disease comes to an end and the fever disappears. The disease may last for from one to two weeks, but it can drag along for a much longer time and may recur. In most cases healing occurs, but it is also possible for the affected parts of the skin to slough. We must regard pemphigus as among the infectious diseases.

The symptoms are extreme itching and a feeling of warmth, neuralgic pains in the face, tinnitus aurium, and a greater or lesser degree of deafness. The skin becomes scaly and as it peels it leaves the underlying skin more or less red, according to the length of time the lesion has existed.

The treatment is the same as for this disease in other parts of the body. The general treatment consists of cooling diet, rest, and the use of quinine or

antipyrin. The internal administration of Fowler's solution is also sometimes indicated. The local treatment consists in a copious washing of the affected part with weak bichloride solutions, and the subsequent application of zinc oxide, boric acid, or subgallate of bismuth powders. In the more pronounced cases the scalp should be shaved in the neighborhood of the ear, the scales should be removed from the affected parts by thorough washing with green soap, then a solution of nitrate of silver of the strength of two per cent. is to be applied, and finally zinc or ichthyol ointment should be used freely.

The prognosis is good.

*Psoriasis.*—Psoriasis of the auricle is very rare. It is characterized, as in other parts of the body, by a sharply defined, large or small efflorescence, with an infiltrated foundation covered with pearly epidermic scales. This is to be differentiated from other scaly skin diseases by the fact that in psoriasis the scales, when removed, leave a surface which bleeds and appears sieve-like. It tends to recur.

*Treatment* consists in the application to the diseased area of a solution of one part each of salicylic acid and chrysarobin, one and one-half parts of ether and ten parts of flexible collodion, and in the care of the general health, examination being made particularly to ascertain if there is any gastrointestinal disturbance present.

*Seborrhea.*—This is an affection of the auricle of quite common occurrence which develops especially in the depressions. It is less like the moist seborrhea than the seborrhea sicca, in which form of the disease the ordinary secretion of the sebaceous glands is hard and firm. The skin is covered with dirty, fatty, scab-like scales which undergo desiccation. There is no demonstrable anatomical change of the skin. The treatment is the same as for the disease in other parts of the body. Begin by washing the parts with tincture of green soap and then use a salicylic acid ointment or thigenol (an ichthyol preparation). Constitutional anomalies must be taken into consideration.

*Pruritus.*—Pruritus very seldom occurs in the auricle. Romberg reports a case of itching in the left lobe. Every attempt to relieve this itching by scratching with the finger nails brought on a severe attack of neuralgia of the first and second branches of the trigeminus. The treatment is the same as for the disease in other parts of the body. Ointments are indicated: either plain vaseline, albolene, etc., or vaseline combined with iodoform, iodol, carbolic acid, salicylic acid, chrysarobin, or ichthyol. Equal parts of chloral and gum camphor, rubbed together to make a viscid fluid, and applied to the part affected, will frequently relieve a pruritus when other measures fail.

Abscess.—Abscess of the auricle may occur in connection with skin affections, such as eczema, especially where pruritus is marked; the infection being conveyed by dirty finger nails or in some similar way. An abscess may also develop as a result of freezing or of an erysipelatous attack. It may develop from the sting of an insect or from a trauma of any kind, such as piercing the lobe, etc. Swelling, redness, pain, a sense of heat, and fluctuation are the symptoms which indicate the presence of an abscess of the auricle. The condition may become dangerous through a spread of the infection to the cartilage, thus causing a perichondritis. When a perichondritic abscess develops the cartilage is often destroyed, with a resulting deformity, or fistulæ may form.

*Treatment.*—An early free incision, curettage, and wet sterile dressings.

Pernio; Frost-bite.—In this affection we find various degrees of inflammation, according to the degree and the duration of the cold. The lighter forms are characterized by a bluish-red coloration, an ordinary amount of swelling, and very severe itching, which may increase to pricking pains. In other cases, which have resulted from exposure to a more intense cold, the auricle appears extremely swollen, very much reddened, and covered in various places with large blebs, whose contents are of a yellowish or bloody color. The pain is apt to be very great. The severest forms are seldom seen. In these gangrene develops; there is a black discoloration and abscesses form. Ultimately the ear shows varying degrees of deformity. Ears that have been frozen will continue to be sensitive whenever the temperature falls to a certain point. In these cases the swelling, the itching, and the development of nodules, which may go on to form pustules and to ulcerate, often recur. In weakened individuals, especially young anemic girls, frost-bites and chilblains are likely to develop at the beginning of cold weather.

*Treatment.*—In the lighter forms of freezing, the application of cold compresses or poultices saturated with Goulard's extract will be sufficient; in extreme cases of hyperemia and swelling there should be a continuous application of cold by means of Leiter's coil. In regard to the itching and pain, relief may generally be obtained by the local use of tincture of iodine. Afterward, ichthyol ointment should be applied. The following preparations will also be found useful: boric or zinc ointment; an ointment containing two per cent. of silver nitrate or one containing orthoform. In the deep ulcers and also in exuberant granulations, silver nitrate stick should be used. Gangrenous parts should be amputated.

The ears should be protected from cold by ear muffs, and they should receive frequent washings with absolute alcohol. In anemic cases the general health should be looked after. For the relief of the itching an ointment of camphor may be used or the following solution applied.

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Erysipelas.—Erysipelas of the ear is of rather common occurrence. It takes its rise here either primarily, from injured or excoriated spots, *e.g.* piercing the lobule of the ear with unclean instruments for the introduction of earrings; from the wounding of the external auditory canal with unclean instruments while removing cerumen or foreign bodies from it; also following operations; or secondarily, from extension from the face or from the throat through the Eustachian tube and middle ear. The clinical picture, the course, and the termination are the same as when the disease affects other parts of the body. The auditory meatus, at least in the outer part, is generally involved, and occasionally the disease may extend to the membrana tympani. In those cases in which a perforation occurs the inflammation may extend from the middle ear to the mastoid cells. Repeated attacks may cause hypertrophy of the skin of the auricle and external auditory canal, and the resulting stenosis of this canal may be accompanied by a temporary diminution of the hearing. Erysipelas following an operation for mastoiditis with a sudden rise of temperature might possibly be mistaken for a sinus thrombosis until the characteristic appearance occurs when a differential diagnosis is readily made. Iodine or iodoform irritation may assume the appearance of an attack of erysipelas, but with the former there will be no rise of temperature.

*Treatment* consists in the use of ichthyol ointment, which both relieves the tension of the skin and keeps the infectious scales from being disseminated; or applications of one-half to one per cent. bichloride solution. Ordinarily the further spreading of the erysipelas has been prevented through frequent pencillings of the neighboring sound parts with strong tincture of iodine, or nitrate of silver. The use of Hiss leucocyte extract has been favorably reported.

Chosky (*Lancet*, Feb. 4, 1911) finds remarkable relief from compresses of gauze soaked in saturated solution of magnesium sulphate. The dressings should be saturated with this solution every two hours and the inflammatory area inspected at the same time. The general condition and the complications demand suitable treatment.

Gangrene.—Gangrene of the ear is seldom seen. Sometimes it affects the skin alone; at other times the cartilage is also affected; but there is always more or less extensive loss of substance. As causes we have a preceding wound or an abscess such as results from measles, erysipelas, or burning and freezing of the third grade. Urbantschitsch reports a case of Raynaud's spontaneous symmetrical gangrene in the upper third of the ear, caused by trophoneurotic disturbances. In the majority of cases the inflammatory process is of long duration and depends on a disturbance of nutrition caused by thrombosis of the vessels.

*Treatment* must consist in the removal of the necrotic tissue and in accelerating the formation of a line of demarcation. The last may be accomplished through the use of antiseptic poultices. Nourishing diet and tonics are indicated. Skin-grafting may be found necessary.

*Noma.*—Noma is a very infrequent affection and observed, up to the present time, only in ill-nourished, young children, especially after typhoid fever, the acute exanthemata, or diphtheria, and mostly in association with otorrhea.

The diagnosis and prognosis are the same as for noma of the cheek. The disease is to be treated locally by daily applications of nitrate of silver, or by means of the Paquelin or galvanocautery; the gangrenous parts are also to be removed with a curette. Constitutionally the treatment should be of a stimulating character, with a liberal diet.

Ulceration.—Ulceration may occur as a complication of burning or freezing; it is also observed in ecthyma, in herpes, in otitis externa diffusa, in diphtheria, and in gangrene. Such ulcers are generally seated on the tragus, the concha, or the lobule. They are superficial and they soon heal if suitable antiseptic dressings are applied. On the other hand, if they are allowed to become deep-seated, they are very slow in healing and are often the starting-point of a very severe eczema. Every eczema may give rise to numerous small ulcers. Ulceration of the auricle may also be due to syphilis or to a tuberculous or a simple perichondritis.

The ordinary ulcerations do not extend to any great depth, and are covered with a yellowish, watery exudate. Those of a syphilitic nature present more marked characteristics; they are deep, crater-like excavations with sharply defined, indurated borders. They are often seen when the chancre has been overlooked. The favorite site of a secondary syphilitic ulceration is the hole pierced for the earring in the lobule; the mechanical irritation supplied by the earring at this point favoring the development of papular infiltration and the formation of small ulcerations on the anterior and posterior surfaces of the lobule. In tertiary syphilis, if the ear is affected by the ulcerative destruction of the gummatous new growths, the underlying cartilage is apt to become the seat of inflammatory action.

Primary syphilitic infection of the auricle has been seen and described by Zucker. The case was that of a man whose ear had been licked by a syphilitic woman. The auricle became greatly swollen, ulcers formed upon the anterior surface of the tragus, and the neighboring glands also became very much swollen. Occasionally the contamination of the ear with syphilitic secretion, as after contact with dirty hands or other infected objects, has caused a primary infection of this organ.

The *prognosis* and *treatment* of ulcers of the ear depend upon the causative factors.

Diphtheria.—True primary diphtheria of the auricle has been observed in rare cases, but it generally occurs in connection with a previous or a simultaneous diphtheritic affection of the throat structures. Secondary diphtheria attacks the auricle by the infection being conveyed through an abrasion of its surface, or by direct extension from the throat, by way of the Eustachian tube and the middle ear. In such cases the auricle and the external auditory meatus are seen to be covered with the characteristic diphtheritic membrane, and when this is removed there will be seen large, irregularly formed, easily bleeding ulcerations of the skin.

*Local treatment* consists in the application of antiseptic solutions and powders.

Othematoma (Blood Tumor).—Othematoma is an exudation of blood into the subcutaneous connective tissue or under the perichondrium or into the substance of the cartilage. Generally, the swelling appears suddenly on the surface of the auricle, in the antihelix or in the concha, and quickly reaches a certain size; in some cases it may be as large as a hickory nut, or it may even involve the whole upper two-thirds of the ear. The swelling, when the subcutaneous structures are alone involved, is hemispherical, fluctuating, with a smooth surface and at times a bluish color. The skin covering the tumor is intact. Fluid blood or bloody serum constitutes the contents of the mass. Where the extravasation is under the perichondrium the depressions and elevations of the auricle are definitely outlined. In many cases there is pain at the outset, but seldom are there other evidences of inflammation. Left to itself, an othematoma, in the course of time, undergoes absorption, or else it remains as a local thickening between the folds of the ear. If inflammation sets in, which may result from the bruising and subsequent necrosis of the tissues and entrance of bacteria into the extravasated blood, the symptoms may be quite severe; otherwise the only symptoms will be a change in the form of the auricle, and a certain feeling of pressure. If the area involved is quite large, the swelling may cause a closure of the external auditory meatus, and so give rise to tinnitus and deafness.

Fig. 1881 Othematoma in the Upper Part of the Auricle. (After Buerkner.)

The greater number of cases of othematoma are found to be of traumatic origin, occurring in those whose ears are much exposed to injuries—such as boxers and prize fighters, acrobats, porters, etc., or in the insane who have chronic dementia and subject themselves to numerous small injuries or as a purely idiopathic affection and without traumatism.

In old, decrepit persons othematoma does occur without trauma, and is then due to atheromatous degeneration of the blood-vessels.

Deformity of the auricle to a greater or lesser extent is nearly always a result of othematoma. Fig. 1882 represents one of the strange and characteristic forms which the organ may assume after healing takes place. The appearance of the auricle is the same

whether the tumor occurs in lunatics or in the mentally sound. Obliteration of the sac is accomplished by the union of its walls, and where the perichondrium has been greatly stretched by extreme distention it contracts upon itself as reabsorption takes place, and adaptation to the cartilage as before cannot occur; the misshapen appearance of the cartilage increases with the continued contraction during the process of adhesion. The ear finally becomes indurated, the skin on the outer surface immovable. Sometimes the organizable lymph which obliterates the cavity enormously increases the thickness of the auricle, but where a thin plastic layer only intervenes the auricle will be reduced in size, and often become even thin and shrivelled.

In a few cases the hematoma is confined to the lobule alone. The disease develops in the form of a circumscribed, soft, purplish-red swelling, more or less sensitive to the touch. This swelling consists of a hemorrhage into the subcutaneous areolar tissue. Owing to

Fig. 1882.—Othematoma of the Auricle, with Areas of Destructive Chondromalacosis, Resulting in Marked Diminution in Size of the Entire Organ. (After Benni in Comptes Rendus du Troisième Congrès International d'Otologie, Bâle, 1858.)

the exposed position of the lobule it is often subjected to injury, but a simple hematoma is of very infrequent occurrence in this locality. Consequently, when we encounter this lesion in the lobule of the ear, we have a right to suspect that the blood-vessels of the part may be diseased, especially if any brain disease or some general disturbance of nutrition should be present at the same time. Hematoma may also occur as a purely idiopathic affection in conditions of mental health, even without a preceding traumatism.

The diagnosis is not difficult. The sudden appearance of a tumor and the discoloration make the confusion with angioma or other form of neoplasm impossible. The disease, however, has been confused with perichondritis, but it is easy to differentiate between the two, since the latter does not occur in the lobule. In transmitted light the swelling is not translucent. The prognosis, for those cases in which there are no brain lesions, is good; in the others, it is not favorable, as the disease is apt to recur.

*Treatment.*—The treatment in certain of these cases is expectant—the simple application of cold compresses. Puncture or incision is certainly not to be advised, except in such cases as become infected. In these cases evacuation of the cavity, with removal of any bits of necrosed tissue by curettage, is immediately indicated. Afterward, small pledgets of sterile gauze should be applied to the irregular surface of the auricle in such a manner as to retain as nearly as possible its contour, and over this a bandage should be so adjusted as to exert gentle pressure. Daily dressings will be necessary. Massage may be used after the tissues have become united to the cartilage.

Perichondritis.—Perichondritis generally begins in the external auditory canal, with edema of the tissues. As a rule it extends to the concha and thence over the other parts of the auricle, until often the whole organ is converted into an irregular, fluctuating mass, in which the folds and prominences of the auricle are obliterated. The meatus is stenosed and the lobule alone remains free from involvement, being separated by a sharp line from the other parts. An increase of the local temperature is present. The neighboring lymphatics are often involved and may become the seat of abscesses; at times, sharp, darting pains, with a sensation of heat, are referred to them. The fluctuating mass, which has formed in the course of a few days, contains a clear, serous, synovia-like fluid, which is never bloody as in the case of an othematoma; it soon, however, changes to pus.

The course of the affection is either acute, lasting for from three to ten weeks, or chronic, lasting for the same number of months. Healing often occurs without any deformity, but in some cases there is a certain amount of shrinking. In rare cases ossification has subsequently taken place. The left auricle seems to be the more frequently affected.

*Etiology.*—The causative factor may be a local infection of the external auditory canal, or the disease may follow a general infection, as in the case of syphilis. In some instances it develops from a trauma or through extension from a furunculosis, from an otitis externa, or from a purulent affection of the middle ear. Occasionally it occurs as one of the sequelæ of the radical mastoid operation, from infection of the meatal flap.

The *diagnosis* is very easy to determine. The condition could be confused only with that of othematoma in its later stage, when sometimes the bluish-red color of the skin, which is dependent upon the presence of a bloody serous exudate, is succeeded by a paler hue, owing to the conversion of the latter into a transparent, syrup-like fluid. The previous history, the course of the disease, and the fact that the lobule is not affected in perichondritis confirm the diagnosis.

The *prognosis* is favorable, in that healing always occurs even if a deformity results.

The *treatment* consists first in energetic, local, antiphlogistic measures (ice-bags). If these fail to help, we may resort, in the early stage of the inflammation, to warm, wet compresses, and later, if necessary, to incision of the most dependent parts. It is also a good plan, after making the incision, to scrape out the necrosed cartilage and the fungous granulations, to irrigate the cavity thoroughly with antiseptic fluids, such as a weak solution of iodine. As a final step a gauze wick should be introduced for drainage purposes and small pledgets of sterile gauze should be so placed on both sides of the auricle as to preserve its contour; the wound should be dressed daily; after the parts have healed massage may be employed to advantage.

Tuberculosis.—Tuberculosis has been observed in the auricle in the form of tuberculous ulceration and in that of a miliary skin tuberculosis (tuberculosis cutis).

*Tuberculous perichondritis* of the auricle has been described by Haug. It affects the concha, which is red and doughy to the touch. The neighboring lymph glands are also swollen and are sensitive to pressure. The skin over the swelling is somewhat red or bluish in color, but it may be pale; it cannot be indented. It must be borne in mind that these tuberculous nodules resemble fibromata, which are common in this region, and consequently a differentiation must be made between the two diseases. In general, these

tuberculous nodules grow very slowly and only rarely show an inclination to soften and break through on the outside. According to Haug, nodular tuberculosis occurs as the result of piercing the ears with an instrument which has been moistened with the saliva of a tuberculous operator, or by wearing earrings which were previously worn by tuberculous patients.

The disease is of slow development. If it is not operated upon, an abscess develops, after the lapse of a certain length of time, and tuberculous ulcers of the skin make their appearance. Then follow fistulæ through which necrosed cartilage can be felt with a probe. If the swelling is incised at an early stage and widely opened up, discolored pus and granulations containing tubercle bacilli will be disclosed, and the affected cartilage—sometimes in the form of a disconnected sequestrum—will also be seen. In cases that are not operated upon early the disease lasts for a period of many months and deformities of the ear often result.

The prognosis of nodular tuberculosis is relatively good, and if the nodules and affected glands are operated upon and removed early, a complete cure may be looked for.

Ossification of the Cartilage of the Auricle.—A few instances of this affection have come under observation. In these the cartilage was always found to be partially but never wholly affected; the upper part of the cartilage, the helix, the scaphoid fossa, the antihelix, and the fossa triangularis were the localities affected, while the tragus, antitragus, and lobule remained perfectly free.

Ossification does not seem to occur with special frequency at any particular period of life; it has been observed in persons as young as fifteen and in others as old as seventy-five. In a large proportion of the cases the change represents the termination of an othematoma; in still other cases a simple perichondritis has been observed to give rise to the deposit of bone. In many instances the cause is to be sought in trophic changes. These newly deposited bone masses possess all the anatomical features of true bone; the Haversian canals being surrounded by well-formed bone corpuscles, marrow, etc. The process goes on without visible appearance of inflammation and without the subjective symptoms of pain. Treatment is scarcely required. Knapp has in one case extirpated the bony cartilage.

New Growths.—*Hypertrophies.*—Hypertrophies are sometimes congenital, sometimes acquired. Under this heading are classed: nevus pigmentosus, nevus vascularis, and nevus cysticus; verruca vulgaris; cutaneous horns; those skin troubles which, starting in other parts of the body, affect the ear by extension or otherwise (*e.g.* ichthyosis, scleroderma, and elephantiasis); and, finally, the thickenings which follow othematoma, perichondritis, the different inflammations, traumata, and freezing.

*Nevus* or mole, whether of the pigmented, the vascular, or the cystic variety, is a congenital anomaly which develops with the growth of the body but causes no constitutional disturbance. It is seldom observed on the ear (Pipino). In old age the change of moles into malignant new growths (epitheliomata) has been observed.

The treatment is preferably surgical—excision and suture; the galvanocautery may also be used.

*Papillomata* or *warts* (verruca vulgaris) should be removed by excision. A less desirable method is to remove the growth by the application of fuming nitric acid, of pure carbolic acid, or of trichloracetic acid, or by means of the galvanocautery. After the growth has been removed it is always wise to cauterize the base and endeavor to prevent a recurrence. They generally occur on the lobe.

The *cutaneous horn* should not be regarded as a neoplasm but as a pure hypertrophy of the skin. It consists of squamous epithelial cells, hypertrophied papillæ, and fibrous tissue, with a small blood supply. Its attachment to the skin is very slight and the growth may be easily removed. Buck reports a case where the horn grew to be three-quarters of an inch in height and three-quarters of an inch in breadth at its base (see Fig. 1883). It is often scratched off by the finger nail, but when this happens the horn is generally reproduced. The use of the Paquelin cautery, after the removal of these horns by the knife or curette, prevents their recurrence.

The hypertrophic skin diseases—ichthyosis, elephantiasis, and scleroderma—are very seldom seen as independent affections of the auricle. These cutaneous diseases, as a rule, affect the skin of the other parts of the body as well as that of the ear.

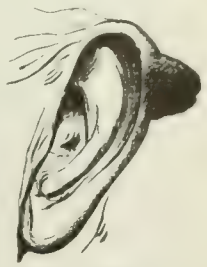

Fig. 1883.—Cornu Humanum of the Auricle, about one-half natural size. (After Buck.)

*Ichthyosis.*—Ichthyosis congenita is a very rare affection and never manifests itself on the ear alone. Under this heading are included those cases of intrauterine hyperkeratosis of the entire skin which are characterized by increased formation and exfoliation of the lamellæ of the skin. In its growth the fetus develops a skin absolutely like a coat of mail; the individual plates of skin being separated by deep furrows, as are the plates of a metal armor. This form of hypertrophy causes the skin of the fetus to contract to such a degree that the mucous membranes are everted and brought to the outside (eclabium and ectropion). It is obvious that such a fetus either dies in utero or in rare cases lives only for a short time after birth.

*Elephantiasis.*—Elephantiasis of the entire auricle has seldom been reported. In Haug's case the ear was very large, its measurements being as follows: circumference, 73 centimeters (29 in.); longitudinal measurement, 12.5 centimeters (5 in.); breadth, 7 centimeters (2.8 in.). Histologically, it presented the characteristics of a lymphangiofibroma, in which there were rather numerous round cells, the result of the early inflammatory disturbance. Elephantiasis can occur after burns, freezing, and eczema, and after any kind of chronic inflammatory process, especially if an erysipelas develops on the site.

*Angiomata.*—Angiomata of the auricle are of relatively frequent occurrence. They vary in size from that of a hemp seed or lentil to that of an egg (Fig. 1884). Their color varies from red and bluish-red to blackish-blue. They are soft, rounded, and provided with knobby prominences of the skin and subcutaneous tissues. Pulsation is sometimes present and the patient complains of a throbbing sensation. At times there is marked tinnitus. These growths are observed on the anterior and posterior aspects of the auricle, on the tragus, at the entrance of the canal, and on the lobule—involving consequently the branches of the auricular, occipital, and temporal arteries. The smallest ones often manifest themselves as vascular nevi, which reach various degrees of development.

The angiomata of the auricle often remain unchanged in size for ten or more years. On the other hand, there are cavernous angiomata which grow with extraordinary rapidity, forming large knotty tumors. Most angiomata of the auricle and its surroundings are congenital, but cases have been observed in which they have developed as a result of a burn or of freezing, as also from the effects of traumatism. A true aneurysm only rarely originates in this way. Pedunculated angiomata are rare.

Injuries often lead to hemorrhages which are difficult to check; spontaneous bursting from momentary

increased blood pressure, such as takes place during coughing, vomiting, etc., may occur. One case of death has been observed as a result of the bleeding from spontaneous bursting of a blood-vessel of the auricle.

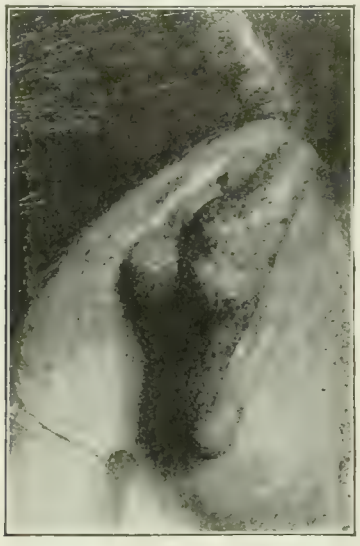

Fig. 1884.—Angioma of the Outer and Posterior Aspects of the Auricle. The tumor consists of three nodules, the outer one of which is double. (Author's case.)

The morbid anatomy of these angiomata is the same as that of other angiomata; that is, they are considered to be formations of enlarged blood-vessels with simultaneous thickening of the vessel walls, or they are due to the formation of new blood-vessels.

They are to be reckoned among the benign tumors only so long as the process of hypertrophy is confined to enlargement of the vessel walls and to formation of connective tissue. In this category belong the simple angiomata, the cavernous angiomata, and the angiofibromata.

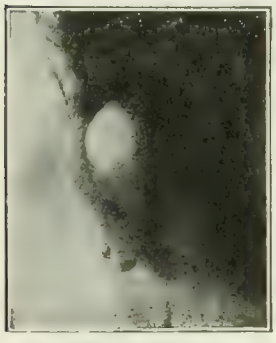

Fig. 1885.—Atheroma or Sebaceous Cyst of the left Auricle. Patient was born with a small tumor, about the size of a pea, on the back part of the left ear. It increased very slowly in size until four months previous to her visit to the Infirmary. It then became painful and increased rather rapidly in size. When removed by operation it measured 36×36 mm. (Author's case.)

Malignant melanotic sarcomata develop at times from a nevus vascularis, therefore these tumors ought to be completely eradicated.

The prognosis is good if the efferent vessel or any of the collateral branches are obliterated and if the vascular mass is entirely removed. Failure, through recurrence, arises from neglect of these two conditions.

Treatment.—Complete extirpation of the tumor, and the successful obliteration of the vessel or vessels which supply the tumor with blood, constitute the proper treatment. In cases of large tumors it may be necessary, in order to prevent the reestablishment of the collateral circulation, to tie the common carotid, and this is deemed justifiable if, when pressure is made on the common carotid, the pulsation in the tumor is diminished. In cases where the growth is of smaller size, ligature of the anterior or posterior auricular or of the external carotid or of the internal maxillary artery may suffice. After this has been accomplished the skin covering the tumor should first be carefully dissected away from the growth, and then the latter should be removed from its bed intact. No suspicious vascular tissue should be allowed to remain. If the skin has been free from disease, the field should be thoroughly cleansed, and the raw surface of the skin should be held in close apposition to the underlying tissues by a sterile dressing and pressure bandage. If the skin, however, is diseased and the underlying cartilage exposed, skin grafting will have to be resorted to. If asepsis is perfect very little after-treatment will be necessary. Injections of liquor ferri subsulphatis and other similar methods of treatment are dangerous because of the possibility of an infecting thrombus being formed.

Electrolysis is the best one of the non-surgical methods of treating these growths. The needle is connected with the positive pole and should then be inserted into the tumor, while the negative pole is placed elsewhere upon the body of the patient.

A few cases of angioma of the external auditory canal have been observed. Angiomata of the drum membrane, with a pulsation that was synchronous with the heart beat, with bulging and redness of the drum membrane, have been reported by Buck and Weir. Destruction by means of the cautery point is the best method of treating such growths.

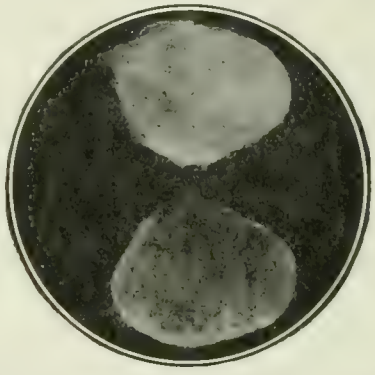

Fig. 1886.—Surface of Section of the Sebaceous Tumor is shown in the upper object. The lower object represents one-half of the cyst wall or shell after the removal of the sebaceous contents.

*Atheromata* (Sebaceous Cysts).—These cysts are usually found in the lobe of the ear, but they have also been seen in the concha and on the posterior surface of the auricle, rarely in the meatus. They are caused by the blocking of the duct of a sebaceous gland. The sac may rupture and thus afford escape for the contents, which consist of degenerated epithelial cells, sebum, and cholesterin crystals.

Treatment.—Incision over the greater convexity of the tumor and careful dissection so as to remove the sac entirely, without rupture of its walls (as was done in the case illustrated in Figs. 1885 and 1886), constitute the best method of treating these tumors. If located in the meatus the cyst may occlude the canal and give rise to tinnitus and deafness, and if not removed it may cause erosion by pressure. These cysts may also break down and suppurate. They should be removed by excision, if possible, as in the case of atheroma of the auricle. If excision is not practicable, the tumor should be incised and curetted and the parts then allowed to heal by granulation.

*Cystomata.*—Cysts develop for the most part in the scaphoid fossa of the ear, in the form of a soft, fluctuating mass. They contain a yellow, thin, sterile fluid,

or one which is more or less tenacious in character; it is only seldom that they contain a purulent fluid. They are often found lying between the perichondrium and the skin, but generally they are seated between the two layers of the cartilage. Rupture of the cartilage seldom occurs. The duration is from a few days to many years. Microscopically, the cartilage shows hyaline degeneration.

Treatment.—In general, it is sufficient to incise the tumor and evacuate its contents; in some cases, however, it will be found necessary to resect the upper or both layers of limiting cartilage. Healing occurs in a short time, and with little or no deformity. If possible the tumor should be removed by dissecting out its sac.

*Fibroma* (Keloid).—Fibroma is more often observed in the ear than is any one of the other kinds of new growth. It usually occurs in the lobule, although it has been seen in the concha. The growths are more common in the negro. Irritation from wearing heavy earrings appears to be a causative factor; so also is the mere piercing of the lobule.

A fibroma of the ear is usually very hard and possesses an even surface. It may grow to be larger than the auricle itself. The growth is made up of fibrous tissue, with but little cellular structure. Cases of myxofibroma, lymphofibroma, and fibrochondroma have been reported.

Thorough removal of the growth is the only method that will prevent its recurrence. To sacrifice healthy tissue is better surgery than to have a recurrence. Sutures should not be employed for uniting the edges of the wound, but in their place strips of sterile zinc-oxide plaster should be used.

Fibromata have been found to exist in the external auditory canal. Fibromata of the tympanic cavity were originally granulomata in which a connective-tissue transformation has taken place at some later date.

*Tophi.*—Tophi are deposits of uric acid salts in the auricle; they are regarded as one of the earliest symptoms of gout. They appear here more frequently than in any other part of the body. They vary in number and in size. Sometimes they are white and contain a milky or creamy fluid; at other times they are as hard as little stones and are firmly attached to the cartilage by an inflammatory exudate. The patient afflicted with these deposits experiences, both before and during an attack of gout, a sensation of smarting and pricking in the nodules. In some cases these deposits will appear shortly after an attack.

Malignant New Growths.—Among malignant tumors the more important are the sarcomata in their different forms. The relatively benign fibrosarcoma is found in the lobule as well as on the other parts of the ear. It is only by the aid of the microscope that a distinction can be made between such varieties of new growths as the angiosarcoma, the chondroma, the cylindroma, etc.

*Etiology.*—The etiology of these growths is obscure. Scars, erosions, moles, a chronic eczema, a nevus, etc., may be the starting-point. Sarcoma of the auricle affects, as a rule, individuals under fifty years of age. The different forms vary as to the rapidity with which they grow. The round-celled sarcomata affect the auricle very seldom, while the fibrosarcomata are the most common among the new growths of the ear. The primary nodule often remains for quite a long time relatively stationary until it receives some traumatism—the usual cause of a renewed activity of growth. This lighting up of the disease may manifest itself either in the form of superficial erosions, which bleed easily, secrete a thin serum, and have their edges markedly infiltrated, or in that of the rodent ulcer, which is of slow development and is situated in the skin and perichondrium. Lupus or syphilis is often mistaken for sarcoma, especially when the characteristic eruptions are wanting, and when, in the neighborhood of the ulcer, neither macular nor papular infiltrations are to be found. In both cases the neighboring lymph glands are swollen. But in syphilis other areas of swollen lymph nodes are to be found. The Wassermann test will give a positive result, in a case of syphilis.

The epitheliomata are therapeutically accessible only in the early stage, and they yield only to extensive excision. The entire auricle, the soft structure of the external auditory canal, the parotid gland, and all the lymph nodes in the vicinity should be removed. The employment of caustics and all other means of treatment tend rather to accelerate their growth.

Another variety of ulcerative new growth is carcinoma. In this variety the ulcer has sharp, bitten-out edges, beset with papillary excrescences, and its floor is covered with discolored, cheesy detritus. The viscid secretion that is given off has a most disagreeable and characteristic odor, and the destruction takes place very rapidly, so that not only the auricle but also the meatus, the neighborhood of the parotid gland, and the deep parts of the temporal bone are eaten away. The glands, even those far removed from the seat of the disease, show evidences of being involved.

In the slowly developing carcinomata there is an abundant formation of connective-tissue stroma which gives a thick, tough structure. On the other hand, in the malignant type we have a stroma rich in vessels and in embryonic connective-tissue cells. In this variety there is developed a rich, thick layer of typical strings of cells which grow through the whole substance of the cartilage, and, after destroying the capsule of the cartilage, they take its place.

While the rodent ulcers can be removed by operation even relatively late, with good results, in the case of the deep-seated cancers, unless taken at the very earliest stage, the involvement of tissue is so great that excision is not always practicable. In both cases the infiltrated lymph glands should be removed.

Nervous Affections.—*Anesthesia of the Auricle,* in association with a similar condition of one side of the head, is one of the symptoms observed in cerebrospinal meningitis, as well as in hysteria. It is generally associated with anesthesia of the external auditory meatus. In the various affections of the middle ear the loss of the tactile and temperature senses in the auricle and its immediate vicinity is relatively frequent.

*Hyperesthesia.*—This condition is observed much more frequently than is usually supposed. It is chiefly found in hysteria. At times it is noticeable in one spot and remains stationary, while at other times it spreads over the entire lobule and auricle.

J. Orne Green describes a case of hyperesthesia which remained after an attack of herpes oticus.

Hubert-Valleroux observed a case which developed subsequently to an attack of tertian intermittent fever which had not been influenced by quinine. In this case it was found possible to ward off or control the attacks by compression of the carotid on the corresponding side shortly before the attack was expected.

Hyperesthesia ought not to be confused with neuralgia of the auricle, nor with the pain which is a concomitant symptom of affections of the meatus, the middle ear, and the auricle.

*Neuralgia.*—Neuralgia of the auricle is an affection of rare occurrence. It is observed most often in connection with an herpetic eruption and is caused by some affection of the terminal branches of the trigeminus, when the pain is referred to its anterior surface, and of the cervical plexus when it is the posterior surface that is affected. It is often attended with congestion and swelling. Pain is excited by slight

pressure, while strong compression will sometimes cause the pain to cease.

*Cramp of the Outer Ear.*—Spastic contractions of the auricular muscles occur very seldom. Romberg states as a reason that these muscles, in man, are only rarely voluntary. This condition has been observed after syringing the ear (Voltolini); on the introduction of a speculum and on the application of friction (Blau); as one of the symptoms of brain lesions (Romberg); as an aura preceding epileptic attacks without visible cause (Wolff); in cases of deafness, in strained attention (Schwartze); and, finally, as a symptom of habit spasms (Politzer). The branches of the facial nerve are always involved. Romberg cites a case of a woman, forty-nine years of age, who, twenty-seven years previously, had suffered from an apoplectic attack with paralysis of the right arm, and in whom, after emotional disturbances, convulsions of both ears occurred, causing them to be rapidly wagged up and down. Tinnitus aurium and headache followed the attack. The case reported by Wolff concerned the retractors and the transverse muscles; the ear was dragged far backward and the muscles were felt to be hard and contracted, their contraction causing a pain which extended from the ears to the back of the head. Subcutaneous section of the muscles cured this case. Schwartze often noticed a quivering motion of the ears in the deaf when their attention was strained, and he noticed an instance of this in a boy of fourteen. In this case no other visible cause than that of intense attention could be discovered. The case observed by Blau concerned a boy of ten years, in whom every rubbing of the ear and every introduction of the speculum caused pain and a quick up-and-down motion of the ears, lasting for some minutes. The external application of the acetate of morphine (from two to ten per cent. with olive oil), stuffing the meatus with cotton, and the use of general constitutional treatment relieved this case.

The treatment must depend upon the cause. When such is not discovered, the treatment can only be symptomatic. Electricity, massage, and constitutional remedies are to be used in such cases, but where they fail subcutaneous section of the muscles is indicated.

Burns and Scalds.—Burns and scalds of the auricle are rare. They may occur as the result of hot liquids, caustics, or molten metals being thrown at or falling upon the head, or, as is often the case, by the patient's falling accidentally, or being pushed, against a hot substance—a stove, steam-pipe, etc. All grades of burning are observed as in the case of other parts of the body. While these burns of the auricle are generally of a superficial character, Hartmann of Berlin has reported a case in which the damage inflicted was sufficiently severe to cause a perichondritis. When the burns involve the walls of the auditory canal or the drum membrane the condition is a serious one. Stenosis of the canal, permanent perforations in the drum membrane, synechiæ between the walls of the canal or between the drum membrane and the walls of the tympanic cavity, permanent loss of hearing, or facial paralysis may result. Caries of the osseous walls of the canal or of the tympanic cavity, mastoiditis, and meningitis have been reported. (For further information in regard to this subject consult the article on *Burns*.)

Incised and Lacerated Wounds.—Superficial injuries affecting the auricle are to be treated in the same manner as those which affect other parts of the body. Neglect here, as elsewhere, is likely to lead to infection, and this in turn may cause a perichondritis. Parts of the ear which are severed must be very carefully sewed together. Cases have been reported in which the ear, after being entirely severed, has been sutured in its proper place, has taken a firm hold, and has healed without deformity. When this operation is performed, the surgeon must see that the meatus is kept open and not allowed to become closed by the formation of new tissue. This is necessary for the preservation of hearing.

The artificial opening for earrings is apt to be torn through and a resulting inflammation may develop in the wound. A very simple plastic operation will correct the resulting deformity; for its performance, local anesthesia will be found sufficient. Hemorrhage must be controlled not by ligatures, but by means of a suture transfixing the blood-vessel. The edges of the wound should be very carefully brought together—at times a difficult matter. Superficial gangrene sometimes occurs and this necessarily gives a cicatricial appearance to the surface after healing has taken place.

While othematoma may in certain cases, as before stated, arise without previous injury, it is dependent in most cases upon trauma of the ear. It is a noteworthy fact that othematoma is seldom seen in the army. In lunatic asylums, furthermore, it has become less frequent since the patients have received more humane treatment. The capacity for hearing is not very much lessened by injuries inflicted upon the auricle, even when the loss of substance is considerable.

Congenital Malformations.—Congenital malformations may be due either to an arrested or to an excessive development; they may be unilateral or bilateral.

*Malformations due to arrested development* include (*a*) absence of the whole or parts of the organ; (*b*) microtia (diminutive ear); and (*c*) congenital aural fistula. The cases belonging to the latter class are by far the most important, as a lack of development in other portions of the auditory apparatus is often found associated with this condition.

*Absence of the Whole or of Parts of the Organ.*—The external auditory canal, the membrana tympani, the ossicular chain—one or all of these may be rudimentary or wanting, or the labyrinth may be only partially developed; and even the lack of development may include the maxillary, sphenoid, and palatal bones, and the structures of the throat. In some cases a lack of cranial development is found. There may be complete bony or membranous closure of the external auditory canal. The external orifice may be a mere depression; there may be a constriction at some portion of the canal or it may be uniformly narrowed.

Gruber describes a case in which the right auricle was very rudimentary and the external auditory canal was entirely wanting. In addition, the following abnormal conditions were observed: The right half of the forehead was more prominent than the left; the left zygoma was smaller than the right; the right nasolabial fold was obliterated; the right eyeball remained partially exposed when the patient attempted to close the eye, and he was not able to wrinkle the skin of the forehead on the same side; the right side of the soft palate was lower than the left, and the uvula was drawn over to the left side; when the patient made an attempt at whistling, the mouth was drawn to the left; the sense of taste was normal; air entered the Eustachian tubes on catheterization; the watch was heard on contact; and the tuning forks placed on the vertex were best heard on the defective side. This case showed defective development of the peripheral portion of the facial nerve as well as a lack of development of the auditory apparatus and the zygoma.

Virchow, cited by Gruber, considers that deformities of the auricle are to be regarded as connected with faulty morphological development in the region of the first branchial cleft.

Congenital absence of the entire auricle is very rare, as some portion of the auricular cartilage covered with integument is generally to be found. Defects of particular portions of the auricle are more

common and possess, except from a cosmetic point of view, but little pathological importance. In this category belong those cases in which the normal inrolling of the helix may fail to take place, and as a result we then have the ape-like auricle, or Darwinian pointed auricle; those in which the antihelix is larger than, and overrides, the helix—the "Wildermuth auricle"; and, finally, those cases in which the auricle is lapped over on itself ("cat's auricle"), with or without the growing together of the helix and tragus (see article on *Anatomy of the Auricle*, p. 725).

*Microta* is comparatively rare and the ear, though diminutive, may be well developed, or it may be malformed. When this latter condition is present it is often found that the malformation occupies some abnormal position, as in front of or below its usual location—a possibility which should always be remembered if an operation to form an external auditory canal is attempted.

*Congenital aural fistulæ* are to be found sometimes associated with other deformities of the ear or with branchial fistulæ, sometimes in otherwise normal ears, in front of the tragus or in the ascending portion of the helix. They are not, as a rule, true fistulæ, but short blind canals from two to six millimeters in depth lined with an epithelium which produces a white creamy secretion, which secretion may cause an eczema of the neighboring skin. They are liable to mild inflammatory attacks with the formation of an abscess from closure of the entrance. They are often hereditary. They occur as the result of nonunion between the various lobules, which coalesce to form the auricle. Congenital fissures—a condition to which the term coloboma lobuli has been applied—are to be found in the lobule.

*Malformations due to an excessive development* include: (*a*) supernumerary appendages; (*b*) abnormal development of a part or of the entire auricle (macrotia partialis vel totalis); and (*c*) supernumerary auricles (polyotia).

*Supernumerary Appendages.*—These are most often seen singly or in a chain in front of the tragus, on a line with one of the transverse clefts, and are composed of reticulated cartilage with its coverings of perichondrium, subcutaneous areolar tissue, and skin; such a structure must therefore be considered to be a true auricular appendage. They are to be found of appreciable size, and sometimes fibers of the muscles of the face are found in them. They occur either with other deformities of the ear or with a normal auricle.

*Macrotia partialis* is not rare and is often found among the women of those races which wear heavy earrings. In such women the lobes are often to be found to be of an enormous size. *Macrotia totalis* is rare.

*Polyotia* is extremely rare. Lauger relates the cases of two double-bodied monsters each of which had four auricles.

The most frequent and most readily corrected of the malformations of the auricle are those in which the cephalo-auricular angle measures 55° or over. This latter condition is not always congenital, but is frequently caused by a faulty style of dressing the hair or of using strings in adjusting the headgear; for this reason it is more frequently to be found among women.

*Prognosis.*—In cases of malformed auricles, when there is an absence of an external auditory canal and the tuning fork is not heard by bone conduction, it is best not to attempt any operative interference unless it be for cosmetic reasons. In cases of unilateral deformity in infants it is almost impossible to state whether they hear or not, and it is therefore best to give an unfavorable prognosis.

*Treatment.*—In the correction of some of the above-mentioned defects otoplasty is of service, but its range is limited. In a case with an imperfect meatus a normal tympanum is the exception, and experience shows that it is practically impossible to prevent a recurrence of the closure of the canal after operation. It is often best, in a case of marked auricular deformity, to remove the entire auricle, with the exception of a stump to which an artificially devised auricle may be fastened.

Supernumerary appendages may be removed, or if associated with auricular defects they may be utilized in correcting the latter at some later date. When they are removed care must be exercised not to cut too deeply, as some of the branches of the facial nerve might be wounded.

Congenital aural fistulæ should be opened throughout their entire length, the lining membrane should then be carefully exsected, and, finally, the whole cavity should be thoroughly curetted and the wound then allowed to granulate.

Excessively large ears may be reduced in size by an operation of which the following are the two fundamental features (see Fig. 1887); the removal of an

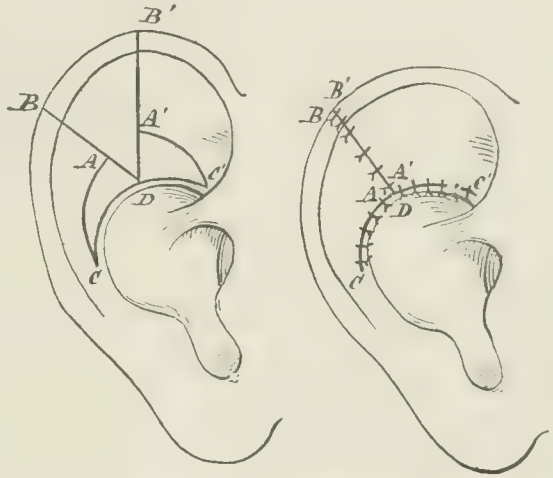


Fig. 1887.—Operation for the Removal of a Wedge-shaped Portion of the Upper Ear. (From Stone, after Cheyne and Burghard.)

elliptical-shaped piece of cartilage (ACDC'A') from the fossa of the helix, and the excision of a triangular section (BDB') from the posterior border of the helix. The apex of this triangle should be located in the posterior portion of the concha. After the removal of these two portions of the auricle, the edges of the wound are to be united with fine interrupted silk sutures.

In the so-called "cat's auricle" the holding of the auricle in a correct position by means of adhesive strips or bandages may remedy the deformity. At the same time, if adhesions are found to exist between the helix and the tragus, they will have to be cut through, and if the cartilage is not sufficiently flexible it may also have to be cut through along the line marking the folding. In some cases it may be necessary, in addition, to hold the auricle upright by denuding a small area on its posterior surface and a similar area on the side of the head, and then causing these two denuded surfaces to adhere together, Fig. 1888. Every case will call forth a certain amount of ingenuity on the part of the operator.

Malposition of the Auricle.—The normal cephalo-auricular angle is considered to be between fifteen and thirty degrees. It is only in cases where the auricle flares (handle-shaped ears)—*i.e.* where the auricle is attached to the head in such a manner as to form an angle of over fifty degrees—that an opera-

tion is indicated for cosmetic reasons. The deformity, if not too marked, may be corrected in childhood by wearing close-fitting caps day and night for a long period, so as to press the auricle close to the head. The cap should be made of some thin material and the crown should be cut out so that it may exert only such pressure as is absolutely necessary on the expanding skull of the child, and at the same time may heat the head as little as possible.

In children of older growth and in adults it will be necessary to perform a plastic operation. It is needless to say that the most thorough asepsis is necessary in the performance of the operation. The surgeon should also be very careful to remove only so much tissue as is necessary to bring the cephalo-auricular angle to a point between fifteen and thirty degrees, if both ears are to be operated upon; if only one ear is at fault, greater care still is necessary in order to make the angle of the one to be operated upon correspond with that of its mate.

Operation.—An elliptical piece of skin, extending from just above the lobule to a point where the posterior surface passes forward to form the upper surface of the organ, is removed from the posterior surface of the auricle (Fig. 1888). From the cartilage thus exposed a similar section is removed; and, in doing this, the operator must be careful not to wound the skin covering its anterior surface. It is best to remove too little rather than too much, for if, upon bringing the edges of the cut surfaces together, it is found that the angle is still too large, a further

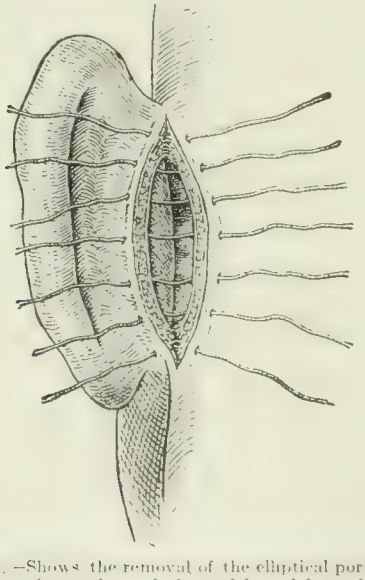

Fig. 1888.—Shows the removal of the elliptical portion of skin from the posterior surface of the auricle and from the skin over the mastoid process, and the method of uniting the surfaces.

portion of tissue may be removed. The edges of the wound in the cartilage should meet and not override each other. The external wound is closed by means of a subcutaneous suture of silkworm gut or by interrupted sutures of silver wire. No sutures should be used to bring the cartilaginous edges together, as they will be brought into coaptation by the closure of the wound in the skin. The dressings are left in place for a week, when the suture should be removed and a light dressing applied and held in place with collodion. A bandage should be worn at night for several weeks.

To make the incision directly through all the tissues of the auricle renders it difficult to bring the wounded edges together, and leaves a visible scar on the anterior surface of the auricle.

In some cases the deformity is not marked, and in these it may not be necessary to remove a portion of cartilage; but in the vast majority of cases the results are more satisfactory when a section of cartilage is removed. The deformity is then less likely to recur.

*Duell's Operation.*—The following operation, devised by Duell for protruding ears, is analogous to Panas' operation for ptosis:*

"The skin on the back of the auricle is grasped by rat-toothed forceps at two points, from one-half to one inch apart and about one-quarter inch behind the free border of the helix. By slight changes of the position of the forceps and dragging the auricle by them back to the scalp, the most advantageous points for, and the direction of, the pull necessary to correct the deformity are determined. These points are then marked by dark indentations made by a hard squeeze of the forceps.

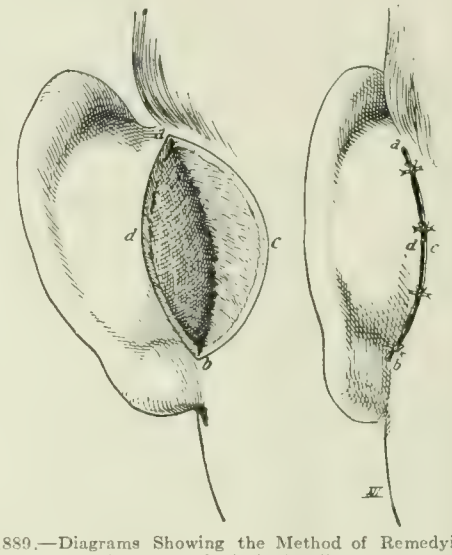

Fig. 1889.—Diagrams Showing the Method of Remedying the Condition Known as "Cat's Auricle." (Laurens.)

"Parallel incisions through the skin are then made, slightly longer than the distance between these marks, one at the postauricular angle, the other about one-quarter inch behind this. The skin is dissected up forming a thick loop.

"Parallel lines are now cut from the points previously marked on the auricle to the anterior border of the loop. The resulting band of skin is dissected up to the points from which the traction should be made. Care should be exercised to avoid any injury to the perichondrium in this dissection. A pair of forceps is now passed under the loop, and the band of skin is grasped and drawn beneath it. This band acting as a lever and the loop as a fulcrum, the ear is now drawn back into the desired position.

"It is necessary at this time to have the loop held down tight to keep it from stretching, and to spread the band to its full width by grasping the free corners with the rat-tooth forceps.

"The desired position of the ear having been secured, the points on the band which come under the loop should be marked, as well as the distance from the posterior border of the loop to which the end of the band extends.

"The band is now pulled out, and, being stretched over a small pad of gauze, is superficially denuded over the area which is to lie under the loop. A quadrilateral piece of the scalp corresponding to the area which will be occupied by the end of the band

*Archives of Otology, xxxvii., No. 1.

is next dissected out. The band is now again drawn under the loop, the denuded surfaces are accurately apposed, and all edges are united by interrupted sutures.

"A thin pressure pad is placed over the line of sutures between the scalp and the auricle, a generous one is placed over the auricle, and a tightly fitting bandage is applied. The dressing should be left on a week, when the stitches may be removed and another pressure dressing applied, as before, for another week.

"It is needless to say that asepsis is essential to success. It can readily be seen that this operation will correct the most exaggerated protrusion of an auricle without interfering with the cartilage, while at the same time it will preserve the normal depth of the sulcus behind the ear." ROBERT LEWIS.

**Ear: Diseases of the Eustachian Tube.**—There are two very important functions of the Eustachian tube, one to admit air into and the other to drain excessive secretion from the middle ear. With the suspension of either of these functions pathological conditions immediately develop within the ear and may extend into the mastoid cells, sometimes into the labyrinth, and not infrequently into the cranial cavity. Infections and inflammatory processes within the nose, the epipharynx, and the Eustachian tube extend and pass through the tube into the middle ear, and over ninety per cent. of all the suppurative processes within the ear and mastoid cells have resulted from a previous infection in the epipharynx and tube. The associated and resulting aural pathology makes the pathology of the Eustachian tube of great importance.

The Eustachian tube varies much in size and contour. There may be much variation without affecting the ear, but a variation such as a narrowing of the lumen may so nearly occlude that the slightest swelling of the lining membrane may result in absolute blocking of the tube. In such a condition marked middle-ear symptoms follow very slight inflammations within the tube. When a tube has a large lumen inflammatory conditions may exist and even extend into the ear without producing symptoms.

Adenoid tissue in the epipharynx often becomes so hypertrophied as not only to limit the normal movements of the Eustachian tube but frequently to cause irritation of the mucous membrane, and not rarely it covers and absolutely occludes the orifice of the tube. A small amount of adenoid tissue in the lateral fossa not infrequently produces disturbance within the tube which if not relieved progresses and produces chronic inflammatory processes within the middle ear. It is not rare to find adenoid masses in the form of nodules within the pharyngeal opening of the tube. This condition almost always induces a middle-ear disturbance.

Adhesions between the posterior pharyngeal wall and the cushion of the tube are of frequent occurrence and are a common cause of faulty ventilation of the middle ear. These bands often form pouches in the lateral fossæ which retain secretion and act as foci of infection to the pharyngeal end of the tube.

Quite frequently an hypertrophied posterior end of a lower turbinate is in contact with the anterior lip of the Eustachian tube and occasionally covers the pharyngeal opening of the tube. A large turbinate causes mechanical irritation to the mucous membrane of the epipharynx and orifice of the tube with which it comes in contact.

New growths other than adenoid hypertrophy are extremely rare within the orifice of the Eustachian tube. I have seen one myxoma and two fibromata. There has been reported one case of a carcinoma seen projecting from the orifice of the tube.

Syphilitic ulcerations, though not common, are not extremely rare in and about the pharyngeal end of the Eustachian tube. I have seen one initial sore upon the anterior lip of the tube in a man who had been catheterized for ear trouble.

The same inflammatory processes are found in the Eustachian tube as in other mucous membranes and these vary from slight hyperemia to intense inflammatory swelling, from marked hypertrophy to pronounced atrophy, and from excessive mucopurulent secretion to a parched dryness. The pharyngeal end of the tube may be covered by a crust similar to those found in the nose in atrophic rhinitis. The Eustachian tube is often affected by pathological conditions within the nose. In suppurative posterior ethmoiditis and sphenoiditis the purulent secretion flows downward over the posterior end of the middle turbinate and over the opening of the tube. Pus in and about the tube can often be traced by the aid of the nasopharyngoscope to its source in the ethmoid and sphenoid cells.

Gastric and intestinal irritation, cardiac and renal disease, vasomotor disturbances due to nasal pressure, to eyestrain, and to sexual and menstrual disorders may produce marked changes in the mucous membrane within the tube. Intemperance in drinking alcohol and in the use of tobacco play an important part in the condition of the tube. Rheumatism and gout are frequent etiological factors. Diabetes, even with a small amount of sugar, often produces marked inflammation within the tube. Chronic lead and arsenic poisoning frequently cause a spongy edematous-looking Eustachian tube.

SALPINGITIS.—Acute inflammation of the Eustachian tube is a very frequent occurrence. A large majority of all nasal infections extend into the epipharynx and into the tube.

The first noticeable change in a beginning inflammation of the tube is an injection of the mucous membrane similar to that seen within the nose at the beginning of an acute rhinitis. This inflammation increases, there begins to be a noticeable swelling, and after a few hours the whole mucous membrane becomes puffed and irregularly swollen. The blood-vessels over the sphenopalatine area become dilated and prominent. The motions of the tube are restricted and the swollen lining membrane is frequently in contact during deglutition and prevents the proper ventilation of the ear. When there is only moderate swelling or when there is an anatomically large tube an acute inflammation may produce no aural symptoms, and in mild attacks there is usually a return to a normal appearance within a few days.

A more severe type of inflammation may begin as, and at first appear like, the simple acute. The swelling is almost always more marked and there is usually more secretion, which is at first of a mucous character but frequently becomes purulent after a few hours. This secretion is often seen protruding from the orifice of the tube. The lateral fossa is usually attacked early in the disease and it is frequently found to be injected and swollen before the tube shows any signs of trouble. On account of the glandular structures in the lateral fossa there is generally much swelling and secretion which may limit the motion of the tube to a marked degree. This frequently prevents the function of the tube before any marked inflammatory process has taken place within its lumen. Upon first inspection the only noticeable change may be that the lateral groove appears narrowed, but as soon as the patient swallows, secretion is forced from the fossa and it will be found that the motion of the tube is restricted.

Acute purulent salpingitis is usually accompanied by more marked stenosis of the tube and more frequent middle-ear extension which is usually of a purulent type. In this condition the mucous membrane covering the tube is much swollen; the glandular structures are often more swollen than the surrounding tissue and appear as nodules. These nodules are

more prominent within the orifice of the tube. More or less pus is always in and upon the tube, sometimes completely filling the lumen. Being the most frequent etiological factor in purulent middle-ear disease with all its grave complications, acute purulent Eustachian salpingitis is of great importance.

Frequent or long-continued acute inflammations may produce many pathological changes within the Eustachian tube, the most common of which is a general hypertrophy. The mucous membrane of the tube is not only swollen and spongy in appearance, but frequently the underlying cartilage becomes enlarged, probably a true chondritis. The cushion of the tube is frequently in contact with the posterior border of the lateral fossa, and often there are formed adhesions across this fossa. The anterior lip of the tube becomes much swollen and except for the reddish tint has the appearance of an edema. The mucous membrane at the floor of the tube has much the appearance of that of the anterior lip. In nearly all of the chronic hypertrophic inflammatory conditions of the Eustachian tube there is an excessive secretion which varies much in character. More frequently it is glairy, tenacious, mucus-like and liable to form air bubbles within the orifice of the tube and within the lateral fossa. These bubbles within the tube are found absolutely to prevent the passage of air when the tube is otherwise not impervious. In these chronic inflammations the blood-vessels which emerge from the sphenopalatine area and run backward over the anterior lip of the tube become enlarged and do not contract under the influence of cocaine.

Less frequently we find a chronic inflammatory process presenting a very different appearance. Instead of a hyperplasia there is an atrophy of the mucous membrane and of the underlying tissue. At times there is more or less atrophy of the cartilaginous wall. There is a general glazed appearance of the mucous membrane, and there are frequently crusts of secretion in the lateral fossæ and at times within the lumen of the tube. Atrophic salpingitis is the most serious type with which we have to deal. There is frequently an associated chronic suppurative middle ear. Often there is a coexisting atrophic rhinitis. Occasionally a purulent discharge from an ethmoid or sphenoid cavity forms crusts upon the orifice of the Eustachian tube and while present may give the appearance of atrophy. After removing these crusts the underlying mucous membrane is usually found to present the appearance of hypertrophy.

Treatment.—In considering the treatment of diseases of the Eustachian tube the great importance of the general condition of the patient must be kept constantly in mind. The results of local treatment may be temporary or even nil if we fail to remove or relieve some causative or contributive pathological lesion of another organ. It is important, as far as possible, to learn the aural pathology before considering the treatment of the tube; for if there is a labyrinthine or central deafness or if there is such an extensive cicatricial process within the middle ear as to prevent hearing regardless as to whether the ear is ventilated or not, it will be useless to treat the tube whatever its pathology. A history and symptoms of otosclerosis, when there are signs of faulty ventilation, should not contraindicate treatment of the tube, for some of these cases are much relieved. It is very important to change faulty habits and to remove, as far as possible, poor hygienic surroundings. The heated rooms of most of the modern houses are so dry that they play no small part in producing pathological conditions within the respiratory tract. Congested nasal and epipharyngeal mucous membranes, including that within the Eustachian tube, are often quickly relieved by simply adding more moisture to the air. This is especially true in children. The admission of outside cold air is not sufficient, for when the temperature is raised to that of the room, it becomes relatively excessively dry. Careful attention should be paid to the food and it is imperative that children subject to these disturbances should be sent early to bed and given all the free out-of-door exercise possible.

Before beginning direct treatment of the Eustachian tube, all pathological conditions within the nose which are liable to affect the tube should be, as far as possible, eradicated. Excessive adenoid tissue in the epipharynx, especially in the lateral fossa, should be carefully removed and adhesive bands in the lateral fossa must be severed. Excessive postturbinal hypertrophy must be relieved.

The mucous membrane covering the epipharynx about the Eustachian tube is more delicate than that of the nose or oropharynx and that within the tube is even more sensitive to irritation than that in the epipharynx; therefore all instrumentation of the Eustachian tube, whether for diagnosis or for treatment, should be carried out with great care and with extreme delicacy of touch. Where the careful use of the syringe or bougie may give marked relief, excessive pressure of bougie or trauma caused by syringe or epipharyngeal applicator will surely result in inflammation and end in disaster. All treatment of the tube should be carried out under guidance of vision and it is imperative that the surgeon should perfect his technique so that he can guide his instruments with delicacy. By application and constant practice the operator of ability can become so efficient that he will rarely produce trauma either in making application to or passing bougies through the tube. By passing the scope through the opposite side and the operative instrument through the same side of the nose to that within the epipharynx upon which we wish to operate we are enabled to proceed with precision and to accomplish desired results with much less trauma to adjacent structures than when working blindly or by the sense of touch.

Stimulating drugs which are not only tolerated but may be of marked benefit within the nose or pharynx may cause intense reaction within the Eustachian tube and it is advisable to begin with a weak solution and gradually use stronger until the desired reaction is obtained. We have found argyrol to be one of the most efficient and at the same time safe drugs for use in the treatment of the inflammatory and infectious conditions within the Eustachian tube. It can be used from ten to forty per cent. in strength and is best used by injection through the Eustachian syringe. Two or three drops are usually sufficient and they should be expelled with little force.

In acute salpingitis, with swelling and blocking of the tube much relief may be given almost immediately by injecting a solution of cocaine two per cent. and adrenalin 1 to 6,000. In cases of acute secretive middle ear with bulging of the membrana it is almost always possible to reestablish drainage in this manner through the tube and give relief to the ear symptoms. A twenty to thirty per cent. argyrol solution injected about ten minutes after the cocaine and adrenalin will help to abort a large number of middle-ear inflammations. In young children if it is found hard to use the scope and tube instruments, good results are often obtained by having the patient in the Rose position with the head inclined toward the affected side. A few drops of cocaine and adrenalin solution are dropped into the nose and allowed to flow backward over the turbinate and into the tube. If after a few minutes, relief follows this solution, argyrol should be used in the same manner. Many ears can be saved by the early treatment of the acute processes within the Eustachian tube.

In the tube, which either from acute inflammation or more frequently from long-standing chronic inflammation has become hypertrophied and strictured, a careful and persistent course of dilatation with the

cotton-tipped bougies will in a large percentage of cases give good results. It is best to begin with very small tipped bougies and increase the size as the tube becomes dilated. Only with moderate pressure should each be used and the pharyngeal end of the tube and the entering bougie should be constantly watched while the bougie is being passed, for in this way any buckling of the wire or deflecting of the tube can be recognized and the bougie can be slightly withdrawn and again advanced. Slight rotation of the bougie often facilitates its passage by mucous membrane folds and pockets. The bougies to give the best results should be sterile and dry until the time of insertion when they can be dipped into a sterile cocaine solution or a sterile oil like albolene. When we wish to produce a slow dilatation the cocaine solution should be used and when the cotton tip is within the strictured area it should be allowed to remain *in situ* for some few minutes. The swelling of the cotton fiber produces constant and increasing pressure but this increase is not sufficient in degree or extent to produce trauma. It is well to inject a solution of argyrol into the tube after the passage of the bougie. In most cases it is best to pass the bougie every two or three days until a patent tube is established after which it should be passed once a week for several times.

Solution of nitrate of silver from two to ten per cent. is of service in the treatment of the chronic hypertrophic conditions in the lateral fossæ and upon the cushion of the tube, but it should be used within the tube, if at all, with great care.

In purulent semiatrophic conditions much relief can be obtained by the local application of thigenol and glycerin (a dram to the ounce). It can be applied to the epipharynx by a cotton-tipped applicator and can be carried into the tube through the Eustachian syringe.

The vapors of tincture of benzoin, oil of eucalyptus, camphor, menthol, ammonia, iodine, or other stimulating drugs can be used when we wish to produce a general stimulation of the mucous membrane lining the tube. Vapors are best applied through a Eustachian catheter using only sufficient air pressure to carry them within the tube.

EDGAR M. HOLMES.

**Ear: Diseases of the External Auditory Canal.**—TUMORS of the external auditory canal are chiefly benign and of these the most common is exostosis.

*Exostosis* arises in the course of a chronic middle-ear suppuration of long standing or after fracture through the temporal bone. Exostosis may be single or multiple. Frequently one finds two little mounds lying opposite each other in the external canal near the fundus. This appearance is sometimes taken for a polypoid growth, but if one examines with a probe he will find the skin drawn tight over the tumor-like mass, which does not yield to pressure. The removal of an exostosis is best accomplished by an operation which attacks the canal from behind the auricle. Operation through the canal for the removal of exostosis is usually unsuccessful and unsatisfactory from every viewpoint.

FOREIGN BODIES.—Children not infrequently put foreign bodies into the external canal, either because some irritation, such as chronic eczema is present from associated chronic purulent discharge, or sometimes in play. One finds peas, coffee-beans, beans, small sticks of wood, beads, glass balls, lead-pencil ends, seeds of plants, cotton, etc. Insects frequently find their way into the external ear attracted by decomposing pus. Fleas, bedbugs and beetles crawl in while the patient is sleeping on the grass or in an unclean bed. Clinically it is important to know whether the foreign body has remained unchanged or is the underlying cause of secondary disease. Thus beans may gradually dry up in the canal, but if water is introduced they may swell and sprout. A second important clinical point is the situation of the foreign body in the canal. If the foreign body is heavy, then it may reach the fundus of the canal or even penetrate the drum and enter the tympanic cavity.

A child, four years of age, came under my care at the New York Eye and Ear Infirmary, with the history of a stone having been placed in the right ear by a playfellow. The foreign body could not be seen, but was felt deep in the canal. A superficial attempt at extraction was fruitless and I advised external operation. In my absence attempts at its removal were made by three other physicians, without success. On the following day a radical operation through the mastoid was performed and the stone was found lying in the tympanic cavity, with one sharp end in the aditus ad antrum, the other in the tympanic orifice of the tube. It was necessary to exenterate the cavity by performing a radical mastoid operation. Besides the stone the ring of a broken curette was also found. The child made a good recovery with slightly diminished hearing.

*Symptoms.*—Children frequently forget the presence of a foreign body which may become surrounded by wax and remain without symptoms for a long time. Consequently hardness of hearing ensues. Living insects in the external canal produce intense irritation and noises. Foreign bodies associated with chronic discharge produce irritation and inflammation of the skin of the canal, sometimes diffuse external otitis. If the skin of the canal is wounded or if there is an injury of the drum membrane bleeding may take place from the external canal. Sometimes severe general symptoms and brain symptoms may arise, which may be dealt with surgically.

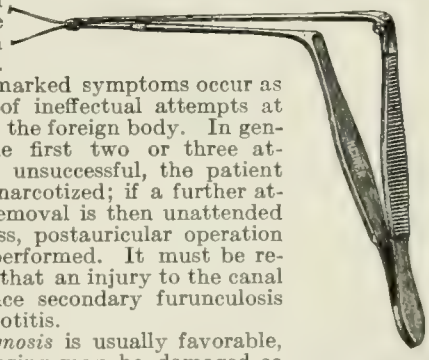

FIG. 1890 - Sexton's Foreign-body Forceps.

The most marked symptoms occur as the result of ineffectual attempts at removal of the foreign body. In general, if the first two or three attempts are unsuccessful, the patient should be narcotized; if a further attempt at removal is then unattended with success, postauricular operation must be performed. It must be remembered that an injury to the canal may produce secondary furunculosis or external otitis.

The *prognosis* is usually favorable, but the hearing may be damaged as a result of the necessary operation.

*Treatment.*—If the foreign body does not swell up, an attempt may be made with a syringe to dislodge it. Special curettes, hooks, and forceps are to be had from instrument dealers to remove foreign bodies. The larvæ of insects should first be killed by dropping in the ear oil of turpentine or other non-irritating drug, and then the ear should be syringed. Steel or iron particles may be withdrawn by means of a magnet. After removal of the foreign body the canal must be carefully treated in order to avoid infection. It should be wiped with alcohol ninety-five per cent. or syringed with a weak formalin solution, and strips of antiseptic gauze should be introduced.

CERUMINOUS PLUGS.—One is very frequently called on to remove impacted wax from the external auditory canal. If the wax is soft this is quite easy to do, but if through accumulation of sand, metal filings, hair, etc., a firm cement is formed, it sometimes requires much time and patience.

Cerumen is a normal physiological secretion, and is formed only in the cartilaginous portion of the canal. It is increased by any irritation of the canal, such as

the use of soap, end of a towel, toothpicks, ear spoons, etc., and is frequently pushed deeply into the fundus by such procedure.

Soft wax is easily washed out with a warm bicarbonate of sodium solution. A simple smooth wire ring curette will help to remove the stubbornly adherent particles. The entire performance should always be done under perfect illumination of the canal.

If the wax is impacted, a solution of bicarbonate of sodium in glycerin and water should be dropped into the canal at frequent intervals for three days. The wax can then be removed with little difficulty. Sexton's foreign-body forceps and Alexander's syringe greatly facilitate this maneuver. Following removal, the canal should be carefully sponged with ninety-five per cent. alcohol, followed by a very thin insufflation of a fine dry antiseptic powder. All of this to avoid a possible furunculosis.

Otitis Externa Furunculosa.—Otitis externa follicularis, furuncle of the external auditory canal. Furunculosis of the external auditory canal is the result of infection of the glands. The first effect is

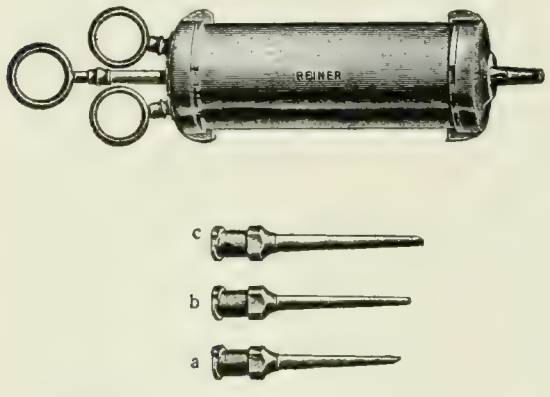


Fig. 1891.—Alexander's Syringe for the External Auditory Canal.

closure of the gland openings. The secretion is now retained in the glands and follicular inflammation results, which, combined with the activity of microorganisms, leads to abscess formation.

The follicular inflammation is always limited to the membranous canal since the bony canal contains no glands. Frequently follicular abscess is multiple from infection of adjacent glands through contact. In constitutional diseases, bad nutrition, chronic eczema, and exostosis of the canal, follicular inflammation is encouraged. Every disease of the canal which is combined with itching may lead to furunculosis because the patient scratches the ear.

*Symptoms.*—The most important subjective symptom is severe local pain, which may cause sleeplessness. When the jaw is moved the anterior canal wall is also moved and the patient has pain, therefore, upon speaking and chewing. The temperature is usually not elevated.

One should avoid introduction of a speculum or pulling on the pinna. Usually all the walls of the canal are swollen. In neglected and severe cases the condition may involve the entire cartilaginous external ear. Therefore, there may be swelling and pain over the mastoid and parotid gland, extending even to the lower eyelid. Under such a condition, movement of the head and neck is limited and the head is held in an awkward position.

The course is usually favorable but may be very prolonged, because as one furuncle gets better reinfection may occur. If treatment is neglected circumscribed granulation masses may form which repeatedly increase in size, filling up the entire external canal.

*Diagnosis.*—Frequently the furuncle is directly visible and with care one may examine the fundus of the canal. Usually it is impossible to investigate the depths of the canal at the first sitting but after tamponing carefully with xeroform gauze, pus and crusts may be removed. If the canal is filled with granulations it is sometimes necessary to snare or curette them. One must differentiate and determine the possibility of suppurative mastoiditis. Sometimes mastoiditis and furunculosis exist together as complications of a middle-ear suppuration. One must exclude also erysipelas.

*Treatment.*—In the beginning of otitis externa, as long as the canal remains swollen and there is no sign of abscess formation, conservative treatment is in order. One may use aluminum acetate one to six, or alsol in one per cent. solution. If there is no improvement then apply heat. The vaccine treatment is sometimes very helpful. By this means I have cured cases which existed for months. The autogenous vaccines have, in my hands, been disappointing. The patient should take only fluids or broths and should speak little. All activities which increase blood pressure should be prohibited and the bowels should be kept open. If an abscess has formed, incision must be made with a small curved bistoury under gas anesthesia. The abscess cavity should now be wiped out with pure carbolic, followed by dehydration with ninety-five per cent. alcohol. A stripe of dry sterile gauze should then be packed into the canal and changed on the following day. This method has proved very satisfactory.

Local anesthesia by ethyl chloride or infiltration with a needle is unwise. To prevent recurrences one should advise the patient against scratching the canal under any conditions. If he is intelligent, however, one may allow the use of a cotton-wound toothpick dipped in alcohol to be followed by the application of boric acid ointment or white vaseline.

Eczema.—Every case of furuncle or of middle-ear suppuration can finally lead to eczema of the external canal. Canals with thin, vulnerable skin are especially inclined to scaly eczema. Thick, fatty skin lining the canal, with rich, ceruminous glands, is more likely to be associated with wet eczema. Patients sometimes produce eczema artificially by scratching the canal with hard, rough, or unclean objects to relieve the sensation of tickling or itching. Toxic eczema may occur after the use of certain drugs, such as iodoform, isoform, or after chemical applications, such as ethereal oil, chloroform, camphor, Peru balsam, thymol, etc. Eczema may also arise from injury, especially from unskillful tamponing of the external canal and also from certain foreign bodies. A prolonged maceration of the skin in the canal as the result of repeated applications of drugs in chronic middle-ear suppuration or in cases of swelling objects, such as beans, can often produce an acute eczematous inflammation of the external canal with stormy symptoms. Finally without special cause, eczema of the external canal occurs in poorly nourished individuals. Here belong those cases seen in rickets, chronic lung tuberculosis, marasmus, anemia, diabetes, and untreated lues. Children with bad digestive disturbances are sometimes attacked. In the suckling age, nutrition plays an important rôle, for eczema of the external canal is more frequently observed in artificially fed infants than in well-nourished breast-fed children. On the contrary, overnourished children may also show the same symptoms. Intertrigo sometimes arises between two skin surfaces which touch each other, especially behind the ear, along the line of insertion of the pinna, in sucklings and older children.

*Symptoms.*—The external canal is swollen and

collections of crusts and scales prevent the drum membrane from being seen. In wet eczema a high degree of swelling may occur with complete occlusion of the external canal. Not seldom acute eczema of the pinna sets in with marked swelling and redness of the skin, followed by blisters and pustules. In cases of chronic scaly eczema the skin of the canal is strikingly thin, atrophic, and easily wounded. It is then covered by a layer of easily removable crusts. In chronic eczemas slight mechanical irritation suffices to produce a profuse lymphoid secretion from the canal.

Eczema of the external canal shows a special inclination to recur. The canal may remain for a long time normal. Then large crusts and flakes form, and if these produce mechanical pressure upon the skin, the dry, scaly eczema may become a wet eczema. In such cases the wet eczema extends very quickly to the region surrounding the canal opening. The skin becomes extensively involved, fissures and crusts form, and in the cold season the skin may bleed easily. Especially in cases of exostosis in the external canal recurring wet eczema is to be feared. The epidermis layer of the drum membrane is usually unchanged in eczema of the canal but in other cases there exist swelling, maceration, and desquamation, and injection of the vessels along the hammer handle.

When strong irritating substances are used in the external canal the drum membrane may become inflamed, swollen, and even suppurative. The glands in the region of the ear are enlarged and sometimes painful. The upper group of the superficial glands in the neck and those of the inner surface of the lower jaw very soon swell up. On the contrary an increase in the size of the mastoid glands is relatively seldom observed. Itching is a very disagreeable symptom of canal eczema. Annoying itching disturbs every desire to work and leads to headaches, fatigue, and diminished attention; therefore children with this condition frequently are poor scholars and are thought to be heedless and inattentive. Long-continued itching may produce nervous symptoms such as twitchings of the face and neck, psychic symptoms, and in rare cases epileptiform seizures. In chronic eczema of the external canal one sometimes finds a foul-smelling yellowish or yellowish brown, thin secretion.

Functional tests show diminution of hearing to a slight degree, but if the fundus of the external canal is filled with crusts then there is significant diminution of hearing, especially in cases of wet eczema, where the fluid secretion fills the bony canal and covers the surface of the drum.

For the decision of the question whether eczema of the external canal is present, in addition to middle-ear disease, it is sometimes necessary to wait several days. In such doubtful cases strips of sterile gauze should be introduced where there is profuse secretion and should be renewed from two to four times daily. One will then be in a position even in the most stubborn cases to get a look at the drum membrane on the second or third day. A valuable differential aid is the determination of the hearing power at this stage; that is, after removal of the crusts and flakes covering the drum. If marked diminution of hearing exists (from two to four meters conversation speech) a simultaneous middle-ear disease is to be assumed.

*Treatment.*—If there is a known cause for the eczema we must of course treat this cause. In middle-ear suppuration we must secure effective drainage. If the bone is involved a radical mastoid operation is necessary. If eczema occurs in the course of middle-ear suppuration, it is the result of neglected treatment or improper treatment. Such cases of eczema frequently vanish if strongly irritating drugs such as iodoform and isoform are avoided. If there is a constitutional cause this must also be treated in conjunction with the local measures. In acute wet eczema with marked swelling of the pinna or canal, ninety-five per cent. alcohol, in selected cases where it is well borne, is effective, but such applications must be frequently changed.

This may be interchanged with applications of weak aluminum acetate solution. In eczema of the canal applications of alcohol, however, are not as a rule to be recommended. Irrigation of the external canal with water is absolutely prohibited. For moist or scaly eczema applications of salves are effective, especially salve in a collapsible tube. One introduces such a salve upon a sterile strip of gauze and introduces the gauze into the depths of the external canal. Upon taking the gauze out, the crusts and scales are removed. Boric salve two per cent., zinc salve two to five per cent., epicarin two to five per cent., resorcin salve one per cent., are all good. These should be made with lanolin. In severe itching the white precipitate salve, one to two per cent., often works well. If at the same time there exists inflammatory irritation of the external canal or furunculosis, then cycloform, anesthesin, or orthoform is advantageous. Carbolic salve and solutions of boric acid in alcohol are usually not well borne. Applications of dry powder, calomel, etc., sometimes help, but must be used only in thin layers, otherwise they are irritating or produce slag in the canal.

In many cases of chronic scaly eczema, the Roentgen rays bring about surprising results in a short time. It is well in all cases to combine such treatment with arsenic in the form of Fowler's solution. Improvement in the general condition by means of nourishing food, rest in the country, etc., valuable adjuncts.

Congenital Atresia.—Congenital closure of the external meatus is almost always associated with congenital defect of the canal and usually also with more or less significant malformation of the auricle and middle ear.

Congenital atresia goes back to the second month of fetal life. At this time development of the tympanum begins. If the formation of the tympanum is delayed, the immediate result is that the jaw-joint lies directly in front of the pars mastoidea. In these cases the development of the normal external ear is also lacking. In place of the ear opening, the skin covers the site of the external meatus or the external canal is merely a depression, ending in a blind pouch one or two centimeters long. With this malformation there is also associated in many cases malformation of the pinna which may be entirely absent, and is in such cases represented by a more or less amorphous small skin process. In these cases the cartilage of the ear is completely absent. There are other cases in which the ear-cartilage is more or less rudimentary and serves as a partial support for the defective pinna. Cases of congenital atresia with slight deformity of the pinna are very rare. If one investigates the temporal bone in cases of congenital atresia he usually finds a surprisingly large pneumatic mastoid process, against which the auricular fossa of the lower jaw lies immediately in front. The middle ear shows in all cases characteristic anomalies. The lateral wall consists entirely of a compact plate of bone. The tympanic opening of the tube is usually present in the majority of cases. In the minority of cases atresia of the tube exists. In the latter cases, the musculature of the soft palate is also incompletely developed on the side of the malformation (Politzer.) The tympanic cavity is small and narrowed by osteophytes. Toward the tube, the tympanic cavity is usually merely a narrow canal, so that one receives the impression that the bony Eustachian tube extends much further than normally into the tympanic cavity. The bony tube extends usually backward and toward the niche of the oval window. The antrum is small. The inner wall of the tympanic

cavity shows a normal outline; in other cases one finds defects in the bone, covering the facial canal. Sometimes the pathological bony excrescences and connective tissue form barriers, through which the niches of the oval and round windows are narrowed or altogether closed. The tympanic membrane has an irregular outline and adjoins the lateral bony covering of the middle ear, but it is not fused with it. The ossicles are demonstrable in the majority of cases, but always show marked changes. They are small and thick. Frequently there is a defect of the head of the malleus or of the long process of the incus. Sometimes the heads of the malleus and incus are united by a single bone or middle ossicle.

*Symptoms.*—Congenital atresia of the external auditory canal is associated with imperfect conduction of sound and therefore with partial deafness. The hearing distance is in all cases significantly reduced, and amounts to from one to eight meters, conversation voice, scarcely ever more than that. The diminution of the hearing distance is due not merely to the atresia of the external canal, but also to the above-described congenital middle-ear changes. A relatively good hearing distance speaks for a trifling congenital malformation of the middle ear, above all for a patent and physiologically functionating tube. In youthful patients there are practically no subjective symtoms, but adults complain of a certain fullness in the head and ear. Functional tests of congenital atresia of the external canal show all the signs of a severe obstruction to sound conduction. Labyrinth symptoms are lacking either entirely or consist in a moderate diminution in the perception of the higher tones and reduction of the upper tone limit. These symptoms depend upon changes in Corti's organ in the region of the promontory or oval window. The patient conceals the cosmetic imperfection by wearing the hair over the ear.

Acquired Atresia of the External Auditory Canal.—Acquired atresia is either membranous or solid. The solid atresia can be either of connective tissue or bone, or the atresia may consist of both connective tissue and bone. Acquired atresia of the external canal arises: (1) Through trauma; bruises with fissure of the external auditory canal and flap-like separation of the pinna; fracture of the external canal; erosion. (2) Chronic ulceration of the external canal. (3) Diphtheritic inflammation of the external auditory canal. (4) Bony new-growth in the middle ear in the course of, or as an end-result of chronic middle-ear suppuration.

Injuries which lead to a complete division of the external canal and to tearing away of the pinna are rare. They are almost always due to sword wounds, in which the parotid region is injured through a vertically extending cut. The weight of the pinna brings about in these cases a sinking of the flap downward, even if the edges of the wound are immediately sutured together. When healing follows, the divided external segment of the external auditory canal lies below the median level. Thereupon the median end closes externally and the lateral end internally through scar tissue. Fracture of the external canal by direct trauma (horses' hoof, blows from a club) may heal with the fractured parts separated, thus forming an atresia. If this dissociation is trifling there may be no difficulty afterward.

Atresia after cauterization occurs if the cauterizing agent penetrates into the external canal and leads to total destruction of the skin surface of the canal. In these cases the eating fluid, caustic potash, sulphuric acid, carbolic acid, etc., in considerable quantity and at a short distance, flies into the ear. More rarely cases of atresia occur after the patient has himself introduced some corrosive fluid into the canal. The result is not very much affected by immediate local treatment. The ulcerations in such cases are associated very frequently with subsequent middle-ear suppuration. If an atresia arises as a result of inflammation of the membranous external canal or after sequestration of the bony canal, then there exists almost without exception chronic fetid middle-ear suppuration. The stagnation of the fetid pus in the external canal leads to maceration of the epithelial covering and to abscess formation, especially in the region of the bony canal. The granulation formation in the middle ear extends to the external canal and sometimes there results, with the formation of the atresia, a healing of the middle-ear suppuration. Frequently, however, the atresia occurs with periodic improvement of the ulceration in the external canal. The external canal then remains closed for several weeks or months. If the pressure of the secretion in the middle ear is high enough or if a cholesteatoma presses against the atresia, then there occurs a rupture of the atresia and an outflow of pus and cholesteatoma masses. The fistula may continue to exist but may close again periodically. Naturally there exists in these cases the danger that a second outbreak of the middle-ear suppuration will not take place externally but will rupture internally and produce an endocranial complication.

Thus in cases of atresia, after long-continued cessation of the outflow of pus, symptoms of an intracranial complication may arise. Sometimes, also, a radical operation wound heals up with connective-tissue atresia of the middle-ear which can obliterate the previously existing external ear canal. If, in the course of a chronic middle-ear suppuration osteophytes are formed, bony closure of the middle ear and a bony atresia of the external canal can take place, if previously, in the course of the suppuration, the skin covering the bony external canal has become destroyed. Bony and cartilaginous swellings, as well as malignant growths, if they have attacked the canal, may lead to complete erosion of the ear canal.

The *symptoms* depend upon the condition of the middle ear before the closure. If the middle ear was not diseased then the atresia causes a more or less significant diminution of the hearing and also a feeling of fullness in the ear. On the contrary, those atresias which take place in the course of a chronic middle-ear suppuration may remain without symptoms if the hearing power was diminished through the middle-ear suppuration. Only in cases in which middle-ear suppuration exists behind the atresia do the patients complain of regional pains, ear noises, headaches, feeling of heaviness in the head, sometimes with an overflow of pus through the tube into the pharynx. Labyrinthine symptoms may also occur through pressure of the secretion; namely, spontaneous nystagmus, turning dizziness, and disturbances of equilibrium with vomiting.

*Diagnosis.*—The otoscopic picture shows a pouch-like epithelialized closure of the canal. In membranous atresia the appearance may suggest a thickened drum membrane, but the long process of the hammer is neither to be seen nor felt. The atresia also lies nearer to the eye than the normal drum membrane. Furthermore, normal drum membrane, with the exception of the upper anterior margin, shows everywhere a sharp linear border adjacent to the skin of the canal. In doubtful cases the diagnosis may be established by examination with the probe and investigation with the Siegle otosocpe.

Otomycosis.—This condition, which is by no means a rare one, is caused by various fungi belonging to the family of moulds. The chief varities are four in number: *Aspergillus niger, A.flavus, A.fumigatus,* and *A albus.* The latter is rare.

To the naked eye, the aspergilli appear to have a felt-like structure composed of fine filaments which vary in color according to the species. The growth is found deep in the auditory canal, and not infrequently

is attached to the drum, sometimes causing an acute myringitis or even inflammation of the middle ear. Since the excitant is of vegetable origin, it is found chiefly in canals where the conditions for vegetable growth are most favorable; namely, in the presence of heat and moisture. Aspergillosis is, however, seldom associated with chronic middle ear suppuration, probably because the pathogenic microorganisms and their toxins are capable of destroying the fungus, should it chance to enter the canal. Moreover, it is worthy of note that the condition is found most frequently among agriculturists, horticulturists and those whose occupation takes them into damp, mouldy places. Attempts to inoculate healthy ears with the growth have failed. The microscope is necessary for certain diagnosis.

FIG. 1892.—Aspergillus Nigricans. (After Politzer.) *a*, Mycelium covered with numerous fallen spores; *b*, *b'*, hypha; *c*, sporangium, with ripe spores; *d*, receptaculum; *e*, sterigmata, with spores.

*Symptoms.*—There may be no symptoms at all, or the patient may complain of tinnitus, dulness of hearing or itching. When the fungus is especially irritating in character, the canal wall may be reddened, and a slight serous discharge may be present.

*Treatment.*—The fungus must be destroyed by instillations and the detritus removed by irrigation. Pure alcohol (ninty-five per cent.), or alcohol containing from two to four per cent. of salicylic acid destroys the mould. The best solution for irrigation is an alkaline wash to which from 0.2 per cent. to 0.5 per cent. formaldehyde has been added. I have found borolyptol useful in these cases. If there is an associated wet eczema, scarlet red ointment is a very efficient adjuvant. Strong solutions of quinine have been used to kill the fungus. I have had no personal experience with this method. IRVING WILSON VOORHEES.

**Ear: Diseases of Tympanum.**—See *Otitis Media.*

**Ear: Drum-membrane Changes Resulting from Former Disease.**—Inasmuch as the active or current changes of the drumhead and adjacent walls incident to the various diseases are to be dealt with in the more clinical articles, it is here designed to present the sequent and more persistent changes and, in any overlapping of fields, to take the standpoint of the morbid anatomy and the general processes producing them. My topic does not deal with the drum-membrane alone, but also with the related structures; for clinical otology is accepting in slowly increasing degree the teachings of aural anatomy which we owe to Leidy, and is recognizing that the tympanum includes always the antrum and attic as well as the lower cavity, and hence that its outer bony wall must be considered with the membranous. And just as modern anatomy has ceased to lay stress upon those details of structure, like the bony labyrinth, which have a merely picturesque interest but have little developmental or physiological importance, so as pathologists we should slight mere morbid changes, however demonstrable as results, in favor of the study of the perverted processes which they indicate and which it is our clinical duty to combat.

The outer wall (more strictly the lower, as it looks more down than out) of the tympanum consists of the tense or vibrating drumhead, the flaccid membrane above the folds that stretch in both a backward and a forward direction from the short process, and the bony wall (*pars ossea*, Walb) that separates the attic and antrum from the auditory meatus. This last is in the adult an undefined part of the canal-wall; but in the infant it is a triangular process of the squama (the "scute" of Leidy) which can be readily detached from the petromastoid to uncover these upper tympanic cavities (Fig. 1893). From this plate all of the upper and most of the back wall of the canal develops, just as the remainder of the wall is the outgrowth of the tympanic bone or annulus. Hence the region of election for opening the antrum, and the *spina supra meatum* which marks it in the adult, are clearly, at least in infancy, in the squamosal and not in the true mastoid portion of the temporal bone. But it is only the innermost part, corresponding with the undeveloped "scute," which remains a bounding wall of the tympanic spaces.

Something of the same sort may also be said of the original annulus, since the bottom of the tympanum proper almost undermines it, forming a "cellar" (Kretschmann) below. The usual lack in this region of septal folds interfering with drainage makes it far less liable to special involvement than the antrum and attic, although it is not infrequently the seat of persistent caries; and its close relation to the descending part of the facial nerve, the bulb of the jugular and the lower curve of the carotid can render such a caries serious.

FIG. 1893.—Inner Aspect of Squama in its Relation to the Annulus and Ossicles. The scute is partly hidden by the incus and malleus head, but the posterior and descending portions are well shown, with the tegmen roofing in both antrum and attic. From a preparation by Clarence J. Blake.

As the triangular light-spot should constitute the most conspicuous feature of the normal drumhead, so its alterations are among those most easily recognized. Its changes of form, brightness, and position are dealt with in relation to the tympanic inflammations by other contributors; yet some reiteration

seems fair in regard to so important a matter. Based upon the glossy smoothness of its epiderm, the oblique position and the centrally depressed but slightly convex contour of the membrane, the light-spot is generally seen downward and forward from the tip of the malleus-handle, because this part only of the drumhead is at right angles to the line of illumination and of sight and can thus reflect back to the observer the light thrown upon it. The light-spot can be shortened by slight depression, reduced to a point by more marked retraction, altered to a crescent or even to a peripheral line concentric with the annulus by distinct cupping, changed to a more horizontal or vertical direction by localized displacement, or divided fanlike by plications of a relaxed membrane. Its luster may be dulled by edematous maceration of the epiderm or lost when this is extreme or exfoliation is going on; and it is important in this section to note that these, which are often the earliest symptoms in the inflammatory process, are also generally the last persisting vestiges of its course. The light-spot may be simulated by reflection from fluid in front of the drumhead or even from a mass of wax with its greasy luster, when carelessly observed through a poorly illuminated canal; and it may be absent from view simply because the tortuosity of the canal humps up the floor or anterior wall so as to hide the region of the light-spot from view.

Any change from the typical cusp-like triangle of light in the anterior inferior quadrant, or any reflection elsewhere from the surface of the drumhead, is to be closely scrutinized as anomalous if not strictly pathological. Depression of the flaccid "Shrapnell" membrane above the short process usually gives a point of light here which is of evil import, and the prominence of the posterior fold or of any other protruding portion of the membrane can give a reflection from its convex surface. The play of these light-spots under the pneumatic speculum is also full of instruction, not only as to the past and present of the case, but also as giving at times indications for successful treatment.

Fig. 1894.—Right Membrana Tympani, Showing an Oval Cicatrix Closing a Perforation in Front of the Manubrium. Posteriorly a large crescentic mass of chalk occupies the entire thickness of the membrane and stands out above it on both surfaces. From a preparation of Politzer's in the College of Physicians, Philadelphia. (Randall and Morse.)

The color of the drum-membrane may also show much of meaning. Normally of a rather bluish gray, it ought to be transparent enough to show much of the coloration of the parts beyond it; and the milkiness of opacities or the darkness of thinned areas serves easily to differentiate the affected portions. Yet it is fair to question how far we clinicians are really familiar with the ideally normal drumhead; certainly among hundreds of presumably normal school-children I have seen few that even approached to a moderate ideal; and once, in a child with hearing that seemed to be absolutely normal, I found a drum-membrane so delicate that it was almost as invisible as though a microscopic coverglass had been placed across the canal. Such transparency or any approach to it deprives us, to a large extent, of our power to appreciate the extreme obliquity of the drumhead. On the other hand, any opacity makes this conspicuous and leads the beginner to think that such inclination is exceptional. Confusion in this regard is likely to continue so long as text-books teach that the adult drum-membrane differs in its inclination from that of the infant, which every one knows to approach the horizontal. The planes of the drumheads, if extended to meet in the nasopharynx, would form an angle of 155° whether in adult or infant.

Only a totally opaque drumhead, then, shows us solely its own color: in all other cases much must depend upon the degree of congestion of the inner tympanic wall and the degree to which its tint is revealed by the transparency and proximity of the drum-membrane. The promontory is normally of a pale straw-color and about three millimeters distant from the umbo, but depression may bring this or other portions of the drumhead nearer to, or even into contact with, the underlying structures. The opacity may vary from epidermal thickenings or exfoliations or similar changes in the mucosa, to fibrous thickenings of the *membrana propria* or the chalky formations which succeed cellular infiltrations of slight vitality. The thinnings may be cicatrical closures of former perforations or atrophic areas hardly differentiable from such scars. While the thinnings may be non-inflammatory and due to mere pressure, the perforations, scars, or infiltrations point back to antecedent congestion, infiltration, and consecutive changes, and often refute any negative history furnished by the patient.

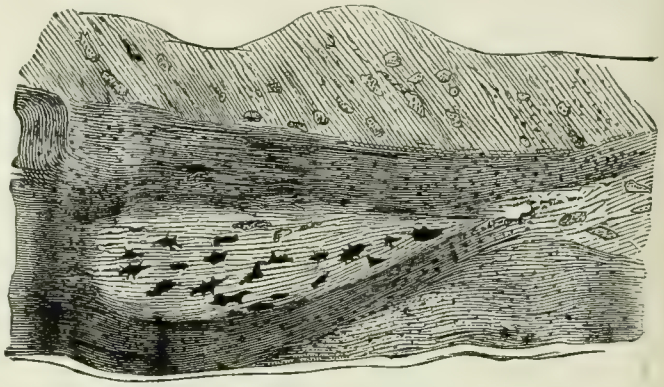

Fig. 1895.—Section of a Partially Calcified Membrana Tympani from a Young Man who Died of Tuberculosis after Suffering with a Purulent Otitis. The layers of the membrane are altered beyond clear recognition, and a small area in the midst of the calcification shows bone corpuscles. (Politzer.)

The diagnosis between epidermal flakes lying upon the drumhead and the fibrous or chalky areas in its substance is not always easy; but good illumination through the well-straightened canal can give enough parallax, especially in the rarer cases in which binocular vision can be used, to clear up many doubts; and the delicate use of the cotton-tipped probe can safely and quickly remove most of the merely adherent material. If the parts are moistened, this may be accomplished more easily, and any deposit of boric acid and such medicaments can be promptly removed. The fibrous plaques can usually be distinguished from the chalky by the interstitial vagueness of the former and the sharp-cut and apparently prominent character of the chalk. Such a chalky area is often thicker than the normal membrane and seems to stand out above its surface (Figs. 1894 and 1896); but it is really seated in the middle layer and is covered by a thin film of living tissue, which on the exterior, as seen in life, can be made to flush by touching it. Such congestion gives a yellowish or orange tint to the chalk-

Fig. 1896.—Retracted Left Membrana Tympani, Showing a Depressed and Adherent Cicatrix below the Umbo, with Calcification of the Margin of the Perforation. Below the short process there is a round disc of chalk apparently standing above the general surface.

plaque or can wholly hide it from view—points that must be taken note of, especially in those cases in which chalky deposits have come to view as though newly formed within a few weeks. Months or years are usually required for such formations. The seat of chalk may be in any portion of the tense membrane, probably never in the flaccid; it is most commonly seen in the intermediary zone between the margin and the manubrium. Peripherally along the annulus and centrally along the malleus-handle uncalcified areas are usually present even in extreme cases of calcification; and it is curious how extensive can be the process without interference with the hearing or with the even excessive mobility elicited by the pneumatic speculum. Virtual ankylosis of the malleus by a rigid membrane is possible, but must be extremely rare, since perhaps the only recorded case is that shown in the accompanying figure (Fig. 1897).

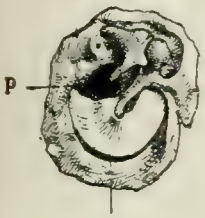


Fig. 1897.

Fig. 1898.

Fig. 1897.—Extensive Calcification of the Left Membrana Tympani. (View from within.) *r*, Narrow uncalcified portion at the lower periphery of the membrane: in front of the manubrium mallei a second narrow strip of uncalcified tissue is visible; *p*, an irregularly shaped opening in the upper posterior quadrant of the membrane. The malleus and the drum-membrane are stiff and immovable. The incus and stapes are disconnected. The latter ossicle, however, is perfectly movable. Similar pathological alterations existed in the right ear. In both ears the patient was able to distinguish whispered words correctly at a distance of eighteen meters (the entire length of the room). (After Politzer.)

Fig. 1898.—Scarred and Depressed Drumhead, with Fibrous Bands within. (From Politzer.)

The margins of perforations, open or cicatrized (Fig. 1896), may show crescentic areas of chalk; and the scar tissue itself may in rare instances undergo such chalky infiltration. In very exceptional cases true bone has been found (Fig. 1895); but usually we have merely the amorphous deposit of lime-salts in the poorly vitalized infiltrating cells, as in other parts of the body. The fibrous thickenings of the drumhead differ principally in having had more vitality and thus having gone farther in the process of organization. They may be found encircling nearly all open perforations and many of those which have healed, forming a rounded rim contrasting more or less strongly with the thin scar tissue or the darker area of perforation. It is largely by the presence or absence of this marginal thickening that we judge whether such a thin area is cicatricial or merely atrophic. In some instances this thickening consists of the displaced fibers of the *membrana propria*, which may be drawn together again in the healing, obliterating or making much smaller the gap to be spanned by new cicatricial tissue.

Far more important than some more conspicuous changes are the fibrous thickenings which may be seen in the drumhead as expressions of adhesions to the structures within (Fig. 1898). These may seriously impede the due mobility of the ossicular chain, even when they are invisible or microscopically small. Many definite and still more numerous indeterminate or accidental bands span the various parts of the tympanic cavities, especially the attic, and may here immobilize essential parts of the conducting mechanism. Through normal or excessively thin membranes the delicate tendon of the stapedius can generally be seen emerging from the opening of the pyramid to insert itself upon the head of the stapes; and about this, as well as about the crura of the stirrup and from them to the walls of the oval-window niche, folds of mucous membrane are apt to stretch which need little inflammatory thickening to become obstructive. Some of them may bind the tympanic membrane to the incus-shank, to the Troeltsch fold, or to the promontory. Similar folds may accompany the tendon of the tensor tympani; and although they are out of sight behind the malleus-handle, their pathological contraction may be noted by the rotation of the retracted manubrium. In the pernicious or sclerotic catarrhs such lesions, especially at the oval and round windows, may cause great deafness with little or no external sign—deafness much greater than that due to even extreme displacement of the ossicles and drum membrane by pneumatic pressure dependent upon Eustachian stenosis. This last, indeed, is often conspicuously absent, if only as evidence that there is sclerosis as the final stage of what has been earlier a hyperplastic process and the tube gapes widely to admit air too freely—in clear evidence that treatment *per tubam* must be medicinal, not mechanical. Some indication of the abnormal condition of the tympanic lining is often furnished in sclerotic cases by Loewenberg's test of inflating vapors of chloroform; for it must needs be a much altered mucous membrane to which chloroform feels cold; yet this occurs even in early stages and at times when visible congestion is present both in the drumhead and on the inner or labyrinthine wall of the tympanum.

The depressed, retracted, or collapsed drumhead of chronic tympanic catarrh has been elsewhere considered, but some points in connection with it may be dealt with here. Primarily this abnormal position tends to affect the drumhead as a whole, for preponderant external pressure is the cause of the displacement. The umbo is deepened, the malleus-handle is foreshortened, and the short process becomes more

Fig. 1899.

Fig. 1900.

Fig. 1899.—Left Membrana Tympani of a Man Thirty Years of Age, in whom, as a Consequence of Coryza, a Marked Swelling of the Mucosa of the Tube has Occurred. The indrawn membrane is of violet-gray color. Relief of the extreme dulness of hearing was secured after three weeks' treatment by inflation. (Politzer.)

Fig. 1900.—The Same Membrana Tympani immediately after the Inflation. (Politzer.)

prominent, perhaps even thorn-like in its appearance, although rather because of the depression of surrounding portions than from its own protrusion; finally, the posterior and sometimes the anterior fold show an equal or even a greater degree of prominence (Fig. 1899). If retraction, strictly speaking, plays a part in producing these effects, it must be due to excessive tension of the tendon of the tensor tympani, and then usually shows itself in a slight rotation and forward displacement of the manubrium. One is sometimes puzzled to explain how the malleus handle can be drawn so sharply in without being arrested by contact with the promontory, for its tip may be lost behind the short process, or in collapsed cases it may be drawn back and seem higher than

the short process (Fig. 1903). Inflation may largely reduce the displacement (as shown in Fig. 1715) moving the malleus as well as the membrane farther outward than should be possible in health, or it may wholly fail to produce more than a tiny bleb-like protrusion, perhaps at the upper posterior margin, in demonstration that air has entered the tympanum, but has not been able to lift the depressed drumhead from its contact or adhesion with the inner wall. Such rigidity of the apparatus is not always due to

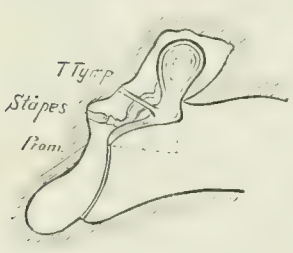


Fig. 1901.

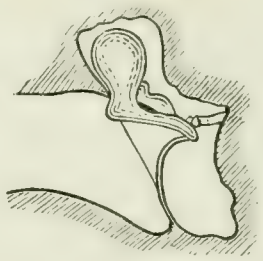

Fig. 1902.

Fig. 1901.—Diagram of Normal Position of the Membrana Tympani, Showing the Inclination of the Manubrium and Upper Segment to the Axis of the Auditory Canal.

Fig. 1902.—Diagram of a Retracted Membrana Tympani, Showing the Manubrium Drawn almost Directly Inward.

attachments to the inner structures; for we must remember that the circular fibers of the membrana propria do much to give the funnel shape to the normal drum membrane (Fig. 1901) and tend to increase this when the other elements of tension are removed, as when the drumhead is cut loose. Hence a deep depression (Fig. 1902) might be maintained or even caused by a pathological increase of the influence of these fibers.

Of some practical interest also are the partial depressions of the tympanic membrane, since they may escape hasty study and the appearance be considered normal; or they may be noted and misunderstood. More commonly at the lower anterior portion the drumhead may show a darker zone bordered peripherally by a sharp line of light reflection. This "Knickung" of the Germans—"kneeing," as I have termed it—is a terrace-like break of the contour of the membrane (Fig. 1904) which may be single or multiple (Fig. 1905) and the peripheral line of light comes from the edge of the undepressed membrane. Why this margin maintains its normal plane is evident from the section shown in Fig. 1836, where, at the margin, the circular fibers are so specially in evidence. When such a depression occurs near the middle of the drumhead it is readily mistaken for the surface-line of fluid within the tympanum (Figs. 1908 and 1909).

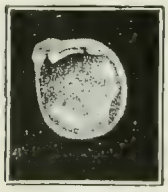

Fig. 1903.—Left Membrana Tympani of a Boy of Six Years with Nasal and Tubal Obstruction. Manubrium drawn up almost out of sight, the tip being higher than the short process: behind it the incudo-stapedial joint is visible, and below and posteriorly the dark niche of the round window is discernible. There is a faint reflection of light near the normal position and a stronger one on the promontory near the stapes.

The epidermal exfoliations from the surface of the drumhead concern us here in several relations. It is probable, as is elsewhere discussed, that the epithelium of the drumhead is capable of reproducing itself more rapidly than can that of any other part of the body. This has great physiological importance, since it is most active at the center and as it were overflows the rest of the membrane from this point, seeming to push the rest of the epidermal layer before it to the periphery or out upon the wall. In health such a migration carries the older skin free of the drumhead, so that not even these tiny scales shall exfoliate upon its surface where they might interfere with the delicacy of its function. This cannot continue, of course, in disease, when the desquamation is exaggerated, as it is after all dermal inflammations; and much subjective noise and annoyance are sometimes occasioned by the presence of such flakes upon the vibrating membrane. This migration can transport superficial extravasations and other lesions to the periphery or clear of the membrane; and it has been claimed that even an artificial perforation, with an eyelet inserted to keep it open, has been observed thus to traverse a part of the drumhead. In medico-legal cases such change of position might give rise to conflicting testimony as to the location of lesions, which although intrinsically of no special significance, might be magnified into important discrepancies

Fig. 1904.—A Schematic Section of an Indrawn Membrana Tympani, Showing Abrupt Change of Plane near the Lower Margin. The edge of the depression, being at right angles to the illuminating rays, reflects them back and forms a narrow glistening line; while the adjacent surface is depressed so as to give back little of the incident light.

The bleb-like liftings of the epidermis, which form in some acute cases (Fig. 1910), are sometimes slow to detach themselves, and may present puzzling appearances; and localized hyperplasia may form wart-like growths or epidermal horns as in Figs. 1906 and 1907. The pearly tumors, of which Politzer has published a notable case (Fig. 1911), have always, in my limited observation of them, occupied the vicinity of a former perforation. They are cystic collections of epithelium and cholesterin and doubtless mark an involuted perversion of the epidermatizing process.

Fig. 1905.—Retracted Membrane, Showing Foreshortening of Malleus Handle, Prominence of the Posterior Fold, and Visibility of the Margin of the Pocket of von Troeltsch as it Passes Forward to the Manubrium. The light-spot is shortened, and beyond it anteriorly are two parallel curvilinear bright lines, marking the edges of abruptly depressed areas of the drumhead, one within the other. From a girl of ten years, with long-standing nasal and tubal obstruction.

Of more importance, by far, is the occasional tendency of the epiderm to overrun the margins of a perforation. This results not merely in "skinning over" its edges and causing it to remain open, but also, by establishing grafts of epidermal flakes upon the mucous surface, in setting up a train of pathological changes the full importance of which we are as yet scarcely able to appreciate. It may prove to be no overstatement if I say that all chronic suppurations owe their persistence, in greater or lesser degree, to the resulting formation of cholesteatomatous material.

Perforation of the drumhead will be considered elsewhere in relation to the suppurating process of which it is a distinguishing characteristic. We may here deal with its production by trauma, by external or interlamellar ulceration, or by the more usual outbreak of serous, mucous, or purulent fluid from the tympanic cavity.

Ruptures of the drum-membrane are generally described as straight or angled linear tears, gaping so little that the blood-stained margins alone mark the site until, on inflation, the lips of the opening are separated by the escaping air. Sometimes they are round, oval, or polygonal; and Politzer seems more frequently to have met them in this form. They are

EXPLANATION OF
PLATE XXXII

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FIG. 1.—Normal left drum membrane as seen by diffused daylight.

FIG. 2.—Normal right membrane by lamplight.

FIG. 3.—Rupture of a partially thinned left membrana tympani by a kiss. Slight ecchymosis of the lower flap-like margin of the tear, with injection of the vessels of the manubrium.

FIG. 4.—Rupture of the left drum membrane by a box on the ear. Ragged rent with extravasation in the wound margins and injection of the vessels along the malleus handle. The rent extends nearly vertically behind the umbo and gapes slightly.

FIG. 5.—Rupture of the left membrane by puncture with a knitting-needle. Ecchymosis at the lower periphery of the rounded opening and injection of the manubrium vessels.

FIG. 6.—Double rupture of the right membrana tympani caused by a fall into the water. Slight injection. A semilunar rent in upper posterior quadrant and a longer, more crescentic tear below. Both are rather parallel to the circular fibers.

FIG. 7.—Ecchymosis on the right membrana tympani back of the tip of the malleus handle.

FIG. 8.—Pigmentation of the region of the umbo in the right membrana tympani—the remains of an extravasation.

FIG. 9.—Fracture of the malleus handle on the left, with malposition of the anteriorly displaced lower fragment. Retraction of the cicatrized neighborhood of the umbo, with distorted reflection of light and crescentic opacity of the lower anterior quadrant.

FIG. 10.—Injection of the cutis of the upper half of the right drum membrane. Slight dulling of the luster or obscuring of details.

FIG. 11.—Radiate injection of the right membrana tympani. The malleus handle hidden by vascularization, and only the short process visible.

FIG. 12.—Acute myringitis of the left membrana tympani. Inflammation limited to upper half, where a hemispherical swelling hides all details except a faint indication of the short process.

FIG. 13.—Acute myringitis of the left membrane, with intense radiate dark injection. Exfoliated epithelium upon the posterior portion and a line of purulent fluid below.

FIG. 14.—Acute myringitis of the right membrana tympani, with two abscesses in the posterior half.

FIG. 15.—Granulations upon the left membrane in chronic myringitis.

FIG. 16.—Chronic myringitis, with concealment of all details by epidermal exfoliation.

FIG. 17.—Chronic myringitis of the left membrana tympani, with radiating injection, swelling of the entire membrane, and a sac-like bagging posteriorly filled with pus.

FIG. 18.—Ulceration of the right membrana tympani in chronic myringitis. Line of pus collection below.

FIG. 19.—Cholesteatomata on the left membrana tympani, after the removal of an impacted mass of cerumen. Injection of the vessels of the manubrium and dulling of the light triangle.

FIG. 20.—Exostoses near the left drum membrane, before and behind the manubrium.

FIG. 21.—Sunken left drumhead in simple acute otitis media, with prominence of the posterior fold, dark coloration of the membrane, and bright point in front of the short process.

FIG. 22.—Strongly indrawn right drumhead in a case of acute simple otitis media. Marked prominence of the posterior fold; broken triangle of light and anomalous light spot in front of the short process.

FIG. 23.—Marked retraction of the left membrana tympani in acute catarrhal otitis. Both anterior and posterior folds prominent; incus shank discernible; "kneeing" of the intermediary zone, and dark coloration of the membrane.

FIG. 24.—Injection and swelling of the left membrana tympani in acute simple otitis media.

FIG. 25.—Exudation in the right drum cavity, with curved surface line visible through the membrane.

FIG. 26.—Exudation with angular surface line in the left tympanum; marked prominence of the posterior fold; punctate light spot in front of the short process.

FIG. 27.—Distention of the upper posterior quadrant of the left membrana tympani by serous exudation.

FIG. 28.—Sac-like distention of the posterior half of the right membrana tympani. Acute otitis media simplex, with diffuse injection of the membrane.

FIG. 29.—Bubbles formed by the air douche in the exudate within the left tympanum.

FIG. 30.—Distention of the left membrana tympani by exudate in simple acute otitis media. Bulging, hyperemia, and swelling of the entire membrane.

FIG. 31.—Crescentic opacity of the posterior portion of the left membrana tympani in chronic otitis media simplex.

FIG. 32.—Peripheral opacity of the right membrane in chronic catarrh.

FIG. 33.—Flaky opacity of the left membrana tympani in chronic otitis media.

FIG. 34.—Sunken, clouded membrane, with prominent posterior fold and quadrate reflex.

FIG. 35.—Radiate atrophic areas in the opaque right membrana tympani.

FIG. 36.—Atrophic left membrana tympani, showing the incudo-stapedial joint.

FIG. 37.—Atrophic and relaxed left membrane in chronic catarrhal otitis.

FIG. 38.—Distention of the posterior half of the right membrana tympani by yellowish exudate.

FIG. 39.—Hyperemia of the promontory in sclerotic catarrh of the tympanum, showing through the retracted membrane.

FIG. 40.—Right membrana tympani, showing hyperemia and swelling of its mucosa, and opacity in the membrana propria.

FIG. 41.—Milky opacity of right membrana tympani, with marked peripheral thickening and broken light spot.

FIG. 42.—Thickened and sunken left membrana tympani, with shining through of promontory; sclerosis.

FIG. 43.—Broadened and distorted manubrium; promontory discernible; sclerotic catarrh.

FIG. 44.—Attachment of the umbo to the promontory in case of marked retraction of right membrana tympani.

FIG. 45.—Adhesion of the upper posterior quadrant of the sunken drum membrane to the chorda tympani and the incudo-stapedial joint. Umbo in contact with promontory.

FIG. 46.—Adherent bands in lower posterior part of tympanum tying down the membrane.

FIG. 47.—Injection, swelling, and discoloration of the right membrana tympani with congestion of the manubrium; crescentic light reflex, and exudation in tympanum visible in lower portion. Acute suppurative otitis media.

FIG. 48.—Small perforation in lower anterior quadrant of the injected left membrana tympani. Exfoliation of epidermis hiding manubrium and leaving but faint indication of the short process. Small (pulsating) point of light from the fluid in the perforation. Acute otitis media suppurativa.

FIG. 49.—Purulent collection in front of lower portion of right membrana tympani hiding details.

FIG. 50.—The same membrana tympani after cleansing. Perforation back of umbo; gray-red membrane with irregular and dim light spot. Acute suppurative otitis media.

FIG. 51.—Pouting perforation of the posterior portion of the right membrana tympani. Membrane red, especially the very prominent posterior half. At the nipple-like apex of its lower part, a small perforation. Light reflex broad and faint, and short process barely discernible.

FIG. 52.—Small perforation in Shrapnell's membrane above the short process, from which a drop of exudation is hanging. Membrana flaccida red and swollen, and manubrium strongly injected. Broken light spot.

FIG. 53.—Recent perforation in the swollen and livid right drum membrane, showing a (pulsating) point of light from the fluid within it. Membrane bluish-red, with sodden flakes of exfoliated epidermis giving here and there tiny glistening reflections. Vessels along malleus handle visible. Fluid in the bottom of the meatus gives a faint crescentic reflex.

FIG. 54.—Small perforation in center of anterior half of membrane in chronic suppurative otitis. Membrane dull, with apparently thickened manubrium, and the mucosa of the inner tympanic wall dark red.

FIG. 55.—Perforation in the upper posterior quadrant of the right membrana tympani in chronic suppuration with caries. The dislocated incus is seen in the opening.

FIG. 56.—The same membrane several months later, showing thickening along the manubrium, the incus gone, and the stapes visible. Granulation masses hang out over the lower margin of the opening.

FIG. 57.—Reniform perforation in lower half of membrana tympani, with thickening of the membrane, especially along the malleus handle, and dulness of the surface. Glistening layer of fluid near anterior margin.

FIG. 58.—Heart-shaped perforation involving the major part of the left drumhead, leaving but a narrow remnant along the manubrium and at the periphery. Discharge has ceased and the tympanic mucosa appears yellowish-red, with a glistening streak posteriorly and branching vessels upon the promontory.

FIG. 59.—Reniform perforation of the middle of membrana tympani, with the tip of the manubrium projecting into the opening, through which the congested inner wall can be seen.

FIG. 60.—Partially adherent central perforation, with marked retraction of the membrane. Manubrium drawn in and up, and posterior fold prominent. A cicatricial band fastens the upper margin of the opening to the congested promontory. Comma-shaped reflection of light.

FIG. 61.—Double perforation in lower part of the left membrana tympani in chronic suppurative otitis media. Manubrium indrawn; light spot broken and tympanic mucosa injected.

FIG. 62.—Two large oval perforations of the right drum membrane, leaving but a narrow band of intervening membrane extending up to the malleus handle. Anteriorly a whitish crescent of chalk deposit. Discharge has ceased and the promontory is reddish-yellow.

FIG. 63.—Large, round perforation, with marked retraction of the right membrana tympani, through the upper part of which the incus is discernible. Promontory red and hyperplastic.

FIG. 64.—Extensive destruction of the right drum membrane, leaving but a narrow periphery, with such retraction of the manubrium that it is almost lost to view. Thickening around the short process, and granular condition of tympanic mucosa.

FIG. 65.—Large perforation in lower anterior quadrant, filled by polypoid granulations of the mucosa of the tympanum, standing out as a raspberry-like mass in the plane of the membrane.

FIG. 66.—Perforation in lower quadrant, through which projects a knob of polypoid granulations hiding the margins of the opening. Manubrium markedly retracted, with prominence of the posterior fold. Crescentic opacity of the posterior part of the membrane.

FIG. 67.—Commencing cicatrization of a perforation below the umbo of a much retracted left membrana tympani, with "cone of light" extending in upon the bluish-gray scar tissue.

FIG. 68.—Scar in anterior portion of opaque and retracted left membrana tympani. Broadening of the tip of manubrium and area of thickening of membrane posteriorly.

FIG. 69.—Central heart-shaped perforation closed by a thin cicatrix. Light spot upon the depressed scar, and thickening of the perforation margins.

FIG. 70.—Central depressed cicatrix of left membrane, with the tip of malleus handle projecting into the opening. Chalk deposit near anterior margin.

FIG. 71.—Almost complete replacement of the left membrana tympani by scar tissue. Marked retraction of manubrium, behind which the incus is visible. Broken reflex upon the indrawn cicatrix.

FIG. 72.—Two rounded cicatrices in left membrana tympani, with retracted malleus handle. The membrane is thin and dark above, showing the descending process of the incus, but gives a marked cone of light below.

FIG. 73.—Cicatrized double perforation, with irregular chalk deposit below in the right drum membrane.

FIG. 74.—Sunken left membrana tympani, with thin cicatrix which closes a rounded perforation below, bellying out after the inflation.

FIG. 75.—Irregular crescent of calcification in posterior portion of the dull left drumhead.

FIG. 76.—Two oval deposits of chalk in the left membrana tympani, occupying the greater part of each half of the membrane, and extending, on either side, close to the manubrium.

FIG. 77.—Right membrana tympani, showing a large calcified area anteriorly, a small one up and back, and a perforation below with chalk deposit in its thickened lower margin.

FIG. 78.—Left membrana tympani, with irregular chalky deposits on either side of a depressed cicatrix closing an oval opening, the lower margin of which is calcified.

FIG. 79.—Dark-red retracted left membrana tympani, with large perforation, out of the anterior portion of which a dark crimson polypus protrudes. Promontory yellowish-red.

FIG. 80.—Cholesteatomatous mass protruding from a perforation in the red and swollen right membrane.

The Human Tympanic Membrane, in Health and in Disease.

Copied by permission from Prof. Kurd Bürkner's Atlas von Beleuchtungsbildern des Trommelfels; Jena, 1896: Fischer.

rarely multiple, and their form doubtless depends upon the relation of their direction to that of the fibers of the *membrana propria*. Helmholtz claimed that rupture of the circular fibers should precede that of the radial, which would explain such radiate openings as Politzer has depicted (Fig. 1914). The majority of those which I have seen were vertical slits back of the manubrium, as shown in Fig. 1913.

Fig. 1906.

Fig. 1907.

Fig. 1906.—Horn-like Growth in a Man Aged Seventy. A blackish conical mass, looking like cerumen, lay in front of the right drum membrane, with its outer part touching the anterior wall of the meatus. When seized with the forceps it was found to be attached to the short process, but was removed by slight torsion and traction. It proved to be a cuticular horn, 6 mm. long by 2 mm. in diameter, composed of cap-like layers arising from the short process. No reaction or recurrence followed its removal.

Fig. 1907.—The Left Membrana Tympani of a Man Thirty-six Years of Age, in a Great Measure Destroyed by Scarlatinal Otitis in Childhood, only a Triangular Portion Remaining Anteriorly. Its place is supplied by a thin cicatrix irregularly depressed, leaving the malleus apparently prominent, although really retracted and fast to the promontory. From the short process a blackish string, slightly bifurcated at its tip, projects forward and downward and moves but slightly under pressure.

Those due to penetration by a vulnerating body are usually round (Plate xxxii., Fig. 5) and are more apt to be followed by suppuration, perhaps from injury to the inner wall. In such a case, as a matter of course, the suppuration would soon efface any characteristic appearance. With rupture of the membrane sometimes occurs fracture of the malleus handle, but it may be readily overlooked, showing no displacement except at the moment of inflation.

Ulceration of the outer surface of the drumhead, as shown in Fig. 1916, is rare; and interlamellar abscess is no more common. The latter has been described as a yellow point, which resembles the localized pointing of pus that is about to escape from the tympanum. The diagnostic point has been made that pressure with a probe will usually indent the prominent and inelastic abscess, and this dimple will remain for some time, as shown in Fig. 1915. The contents of such an abscess are also unaffected by inflation of the tympanic cavity; and, on evacuation, no complete perforation will be found. Such abscesses may burst inward instead of outward (Politzer), as recognized by the disappearance of the pus and the distention of the empty sac when the air douche is used. Toynbee is authority for numerous instances of ulceration found post mortem; they were limited to the cutaneous or the mucous surface and were sometimes extensive. Yet they must be very rarely recognized in life, and such appearances may generally be ascribed to the usual cause of perforation,

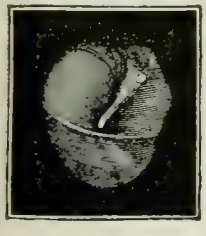

Fig. 1908.—Collection of Fluid Exudate in the Lower Part of the Tympanum, Marked by a Glistening Line Across the Membrane. From the right ear of a young man in the middle of an acute coryza. Cure by inflation. (Politzer.)

viz., the outbreak of fluid from the tympanum. Such an occurrence is very common; and the history of any flow from the ear generally points to such perforation. Few children escape one or more attacks of earache; and these acute inflammations are as often relieved by an escape of exudate through the drumhead as by one that follows the channel of the Eustachian tube. The quantity of the fluid which escapes is, in many instances, not more than a drop or two; consequently it may be wholly unnoticed, and the denial that there has been any discharge may be

Fig. 1909.

Fig. 1910.

Fig. 1909.—Marked Partial Repression of the Middle of the Right Membrana Tympani, in a Case of Chronic Catarrhal Otitis. The lower portion is in about normal position, and the manubrium and upper part are not greatly indrawn; while the middle portion is so abruptly retracted as to form a sharp "knee" overhanging the dark depressed area above it. The appearance presented to the eye is that of a glistening line running across the membrane near its middle and closely simulating the surface line of an exudate in the cavity. In front of the manubrium is visible a whitish ill-defined thickening.

Fig. 1910.—Delicate Bleb on the Drumhead in Acute Myringitis.

entirely honest, however unequivocal the evidence of perforation. In this connection we must insist that there is no anatomical or clinical basis for the claim that a "foramen of Rivinus" should normally be present above the short process. It is absent in the embryo and the infant, and appears with increasing frequency only as the child grows older (in ten per cent. of the children—most of them over ten years of age—which were examined by me for this purpose). In adults such an opening or scar may be noted by careful scrutiny in twenty-five per cent. of

Fig. 1911.

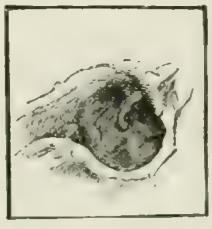

Fig. 1912.

Fig. 1911.—In a young man whose ear affection had lasted a year, there was a tiny perforation in the lower anterior quadrant of the left membrana tympani, and upon the upper part of the drumhead were eight glistening globular bodies of pinhead size arranged in a semicircle. These were found with the probe to be hard and firmly seated upon the membrane. (Politzer.)

Fig. 1912.—Irregular Linear Rupture of Posterior Portion of Right Membrana Tympani, with its Edges in Apposition. (Toynbee.)

all drumheads. Most of these cases can give no history of discharge; yet we often find even grosser lesions with a like negative history. The presence of such an opening or scar confirms my claim that disease in the attic is not necessarily severe and intractable, bad as certainly are many attic suppurations with perforation in the flaccid membrane (Fig. 1918).

The tense membrana vibrans is much the more frequent seat of such an outbreak of discharge from the tympanum, and most authorities state that it is most common in the lower anterior or light-spot region. A summary of 1,000 consecutive cases in my

practice was made by Dr. Barton H. Potts and it shows only twenty-five per cent. at this part as against thirty-seven per cent. down and back, and sixteen per cent. up and back. The Shrapnell perforations were ten per cent. and those called central (often too large for their region of origin to be longer determinable) were less than seven per cent. I feel confident that more extended observation will show that the upper posterior region, which is the site of the most common and conspicuous distention, will be found to have a larger proportion of perforations than that which has just been given.

Fig. 1913.—Rupture of the Left Membrana Tympani. A vertical gap extends almost across the posterior half of the membrane, and the vessels are full, especially behind the manubrium.

While the form of the opening is as varied as its site, it generally begins as a small round yielding of the distended tissues, and only in the very septic conditions, as in scarlet fever and diphtheria, is there a rapid loss of substance by ulceration to enlarge it or even to destroy almost every vestige of the drumhead. Almost always in infancy, and frequently throughout childhood, the perforation is but a pinhole at the apex of the bagging portion of the membrane; and this nipple-like or pouting perforation may be recognized only by the drop of discharge which forms upon it almost as fast as it can be wiped away. The persistence of such a protrusion after an opening has formed doubtless marks some impediment of free drainage; and in adult cases this often has its serious aspect (Fig. 1917). In early life, however, and in the presence of mucopurulent discharge of no great virulence, it may be regarded with less concern. It serves as a complete bar to penetration of medicaments from without, and therefore is an indication for the use of heat by the douche as our best astringent; for the heat can penetrate where the fluid which conveys it to the bottom of the canal fails to pass. It is claimed that such openings are specially liable to clogging under insufflations of powdered boric acid, a phenomenon which depends principally on the insolubility of boric acid in mucus, and which

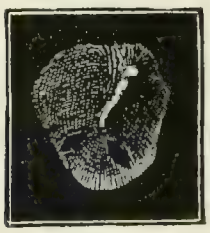

Fig. 1914.

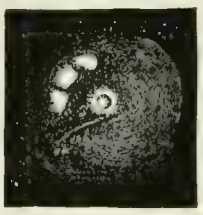

Fig. 1915.

Fig. 1914.—Double Rupture of Right Membrana Tympani in a Woman of Thirty, Produced by a Fall upon the Ear—seen on the Third Day. The two tears have radiating directions, and show marked gaping. (Politzer.)

Fig. 1915.—Interlamellar Abscesses of Right Membrana Tympani, one at Umbo Showing the Pitting caused by Pressure of a Probe. Three others are seen backward and upward. (Schwartze.)

therefore brings it in all such cases under the ban which forbids the use of any insoluble powder. Such incomplete drainage may also afford an indication for operative enlargement of the opening; but incision through such a perforation may serve only to freshen its edges for premature closure and wholly defeat the intention of the operator. It is better to incise, if at all, freely at the periphery of the membrane, avoiding the site of the perforation; but in many cases it seems simpler and better to introduce a pair of fine forceps into the perforation and by separating the blades to cause slight divulsion, thereby securing a more patulous condition with lessened tendency to close. It has been claimed that an ingrowth of epidermis lines many of these pouting perforations,

Fig. 1916.

Fig. 1917.

Fig. 1916.—Ulceration of the Right Membrana Tympani of a Man Sixty Years of Age after the Removal of a Hard and very Adherent Plug of Cerumen. A dark red rough and moist surface was seen in front of the malleus-handle, bounded by a raised edge of cuticle. The remainder of the membrane was nearly normal except for injection, and the light spot was merely lacking in brilliancy. Examination of the ceruminous plug showed that it had been in contact with the ulcerated surface. Healing was prompt under boric acid powder.

Fig. 1917.—Right Membrana Tympani of a Man Thirty-two Years of Age, Recently Recovered from Typhoid Fever. Mucopurulent catarrh of the middle ear of two week's duration. Below the umbo is a reddish-yellow protrusion, yielding but little on pressure, from the point of which the discharge flows, and on being cleansed, a minute opening is visible. General injection of membrane, especially behind the manubrium. Treatment failed until a good-sized opening was made with a paracentesis needle; then prompt recovery ensued.

making it necessary to excise the whole protrusion in order to obtain proper healing. As there is frequently a tendency of the swollen mucous membrane to prolapse into the opening and limit the exit, the application of silver or other astringents to the edges

Fig. 1918.

Fig. 1919.

Fig. 1918.—Right Membrana Tympani of a Boy of Five Years, with Constant Discharge for Three Years. A perforation about 1.5 mm. in diameter was with difficulty seen above the short process, and intratympanic injections brought away epithelial flakes and masses of fetid secretion. The rest of the membrane was slightly opaque, thickened, and injected.

Fig. 1919.—Large Loss of Bone at the Inner End of the Upper Wall of the Meatus, in a Woman Twenty-six Years of Age, in whom the Tympanic Suppuration began in Childhood, and Ceased only a Few Years Since. Membrana tympani dry, gray, and opaque, retracted down and forward from the umbo, atrophic behind the manubrium. Through the opening are seen the malleus-head, the anterior ligament, and the body of the incus with its long process. A very delicate membrane which closes the opening and applies itself closely to the ossicles, bellies out on inflation. Hearing, 0.5 meter for acoumeter, 5 meters for loud whisper. (Politzer.)

of the perforation may cause the tissues to retract and thus favor drainage. The same result may be attained at times by light dusting with boric acid, and the assertion that this medicament will enlarge perforations testifies in some measure to its efficacy.

With any increase in the size of the opening a dark hole may be seen when the occluding discharge has been removed; and in the acute cases any fluid within the opening can generally be seen to pulsate, in evidence that the arterial pulse is propagated into the distended capillaries of the tympanum. The proximity of the carotid has been cited as a cause for this visible pulsation (which may be as throbbingly felt in the inflamed finger-tip). Such pulsation is therefore usually indicative of perforation and is noted only

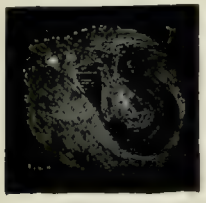

FIG. 1920.

FIG. 1921.

FIG. 1920.—Purse-like Distention of the Upper Posterior Quadrant of the Left Membrana Tympani. (Schwartze.)

FIG. 1921.—Perforation of Upper Posterior Quadrant, such as sometimes remains after rupture of the distended portion shown in the previous illustration.

in or near the opening; yet in rare cases the unruptured membrane has been observed to pulsate, but only when thinned to the verge of rupture. (Compare Fig. 1934.)

Further enlargement of the opening is apt to assume a more oval form, partly because of the obliquity of the membrane and its foreshortening. Near the upper back margin this may make the perforation appear even slitlike; or, if its margin be swollen, no visible opening may be noted. (Compare Fig. 1923) although the curved probe can be readily carried through it. This is the more important since the peripheral perforations at this locality are apt to indicate carious involvement of the shank of the incus or of the bony tympanic margin, and to demand prompt recognition and vigorous treatment. Still larger openings are commonly reniform (Figs. 1923 and 1931) and embrace the tip of the hammer-handle, which may seem to protrude naked into the opening. Such denuding of the malleus is not in reality very common and the cotton-tipped probe will not catch upon it, for the condensed drumhead-tissues still cover it and are well nourished by its vessels. Caries and visible truncation usually follow quickly on actual denudation. Destruction of the drumhead may be complete, leaving no visible remnant; but more often there is a rim of the thicker tendinous annulus recognizable throughout more or less of the circumference, and this may form a perfect basis for regeneration of a cicatricial membrane after the destructive process has exhausted its force.

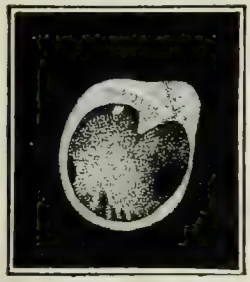

FIG. 1922.—Right Ear of a Boy, Eight Years of Age, with Long-standing Suppurative Otitis after Scarlatina. The membrane is extensively destroyed, leaving but a narrow margin all around, except where a triangular portion remains along the retracted manubrium. The tip of the long process of the incus is just visible posteriorly, the niche of the round window appears behind, and the irregular depressions of the floor of the tympanum may be seen below. Anteriorly, we look into the Eustachian tube, as far as to the isthmus.

The perforation of the drumhead is generally single, but it is not unnatural, when one opening is ill-placed for draining the complex cavity, that another should result from the action of retained fluid. Especially is this the case as regards the attic with its subdivided area, which may require several openings in the flaccid membrane to drain it, irrespective of openings in the tense membrane below. The objection often raised, that high-placed openings (Figs. 1918 and 1921) are ill suited for drainage, is usually specious. Whoever raises this objection ignores the fact that most persons are recumbent at least one-third of the time, and, furthermore, that capillary attrac-

FIG. 1923.

FIG. 1924.

FIG. 1923.—Left Membrana Tympani of a Woman Thirty Years of Age, with Long-standing Purulent Otitis Media. A reniform perforation involves much of the lower half of the drumhead, and a polypus arises by a narrow peduncle in front of the short process. Upon its removal, no perforation was recognized at its point of origin.

FIG. 1924.—Right Membrana Tympani of a Man, about Fifty Years of Age, Showing Four Perforations in the Lower Portion. The narrow, most posterior opening closed under observation. (Patient had laryngeal tuberculosis.)

tion counts for more than gravitation in this matter of draining the tympanum. As stated above, I believe that the majority of perforations are located in the upper back quadrant and are so efficient that they permit of prompt cure with little or no recognizable scar. Perforations occur high up because in this region there is retention of fluid which is not drained away by the normal channel of the Eustachian tube. Yet the occurrence of multiple perforations in the tense membrane should always raise a question as to the existence of a tuberculous process; and when we come to investigate these cases we shall often find that there is a prolonged expiratory sound, if not more marked trouble, at one or both lung-apices, or that the family history shows a tendency to consumption. At times the perforations almost merit the term "sieve-like," as in the cases illustrated in Figs. 1924 and 1925; and if the process is notably painless and the drumhead presents rather a pallid than congested aspect, we may feel nearly sure of the diagnosis even though otherwise unsupported. The fact that the promontory, in the later stages of such cases, is not infrequently denuded of its covering of mucous membrane, or may even be carious, may likewise be regarded as an extremely suspicious circumstance. Miliary tubercles have been noted in the drum membrane as yellow points which rapidly soften and leave perforations; but I cannot say that I have ever recognized them, and I know of no certain means of differentiating them from the more ordinary pointing of retained pus, unless it be in the fact of their multiplicity.

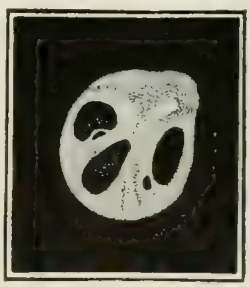

FIG. 1925.—Right Membrana Tympani of a Man, Forty Years of Age, who Died about a Year Later of Tuberculosis. An oval perforation occupies the anterior portion of the membrane, a more pear-shaped one is down and back from the umbo, and a third, of kidney shape, is up and back. Two small and elongated openings are close to the first and the third. The membrane shows plications below the umbo.

The usual tendency of a perforation, of whatever size and however produced, is toward closure. Even the most thorough excision of the entire drumhead has been followed by complete regeneration; and Kessel urged that the tympanic margin should be chiselled away in such cases if a permanent opening was desired. The healing takes place more promptly in youth than in later life and in acute than in chronic cases; yet it is sometimes a far slower process in the case of small than in that of large openings. The reason is that the "skinning over" of the margins by

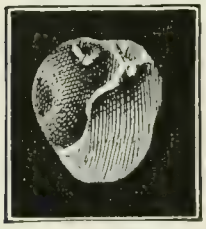

FIG. 1926.

FIG. 1927.

FIG. 1926.—Right Membrana Tympani, in a Boy Seventeen Years of Age, who has Suffered with Chronic Middle-ear Catarrh for Eight Years. Nasopharyngeal catarrh with great swelling of the mucous membrane of the tube. The depressed area rests upon the inner wall and shows the incudo-stapedial joint. (Politzer.)

FIG. 1927.—The Same Drum Membrane as in Fig. 1926 immediately after the Use of the Air Douche, which Raises the Patient's hearing nearly to the Normal. (Politzer.)

ingrowth of the drumhead epithelium suppresses the growth of reparative granulations. The further great importance of this process in the production of cholesteatoma and the renewal or maintenance of suppuration will be dealt with later.

Drumhead healing in its simplest form is seen in many of the acute cases, in which the perforation has been a mere pressing apart of the tissues, especially the fibers of the membrana propria, with little or no loss of substance. The tissues come together and unite as if by serous agglutination, the epidermal and

FIG. 1928.

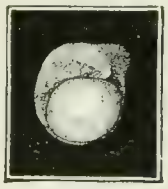

FIG. 1929.

FIG. 1928.—A Large Rounded Loss of Substance of the Membrana Tympani below Reaches up to the Tip of the Manubrium, which Projects slightly into the Upper Margin. It is closed by a delicate cicatrix applied to the promontory and moulded upon its inequalities. The edges of the depression are sharp-cut and overhang, so that the area seems an unclosed perforation.

FIG. 1929.—Inflation of the Middle Ear Forces the Delicate Cicatrix out like a Bubble into the Meatus, where it Seems Larger than the Opening and Hides its Edges and the Handle of the Malleus. In a few minutes the distended sac loses its tension, and becomes plicated as it collapses, soon to resume its old position in contact with the inner tympanic wall.

the mucous epithelium are promptly renewed, and in a short time every vestige of the opening has disappeared. Where there has been loss of substance this must be replaced by new tissue, and in the traumatic ruptures, even when promptly healed without suppuration, there is apt to be enough new tissue to make a permanent scar, often more visible than the inconspicuous rent. Such cicatrices involve only the fibrous layer, as a rule; for the epithelial and mucous surfaces soon lose any altered appearance if the supporting tissue approximates the normal. This it often does, and it is at times easy to overlook large cicatrices or, in recognizing their thinness, to be in doubt as to whether the condition is one of atrophy or of a healed perforation. Most perforations present a thickened margin, which may be recognizable after they have healed and which furnishes the characteristic which distinguishes them from mere atrophic areas. This thickening contains most of the peculiar substantia propria fibers which spanned the site of the opening, and in the healing process these may be drawn back into place; but regeneration of these fibers probably does not occur, although it has often been reported. Some new tissue will be present to unite the separated fiber-ends, but this may be hardly discernible under microscopic study. Most commonly, in openings of any size, granulations form on the margins; they arise mainly from the epidermal layer, and are clinically recognized as a pink or red edging. They grow inward, cicatrizing as they do so, and drawing inward, like a sphincter, any of the old tissues which may be present. Finally, they meet and coalesce. Vascularization or other factors may make this process unsymmetrical, and the new tissue may be even a tongue-like growth which proceeds from one side and closes all but a cleft at the opposite margin. I have observed this especially in perforations healing under the stimulation of a paper patch. This new tissue is soon converted into a fibrous scar, but it rarely has much of the rigidity of the original membrane and almost always shows a flaccidity and undue mobility which are apt to increase, sometimes moving in and out with respiration if the tube be merely patulous (manometric scar.) Hence such scars are generally more or less depressed and may even collapse into contact with the inner structures of the drum cavity (Figs. 1926 and 1928). They may not only fail to serve as parts of the vibrating membrane but may even hamper its movements or those of the deeper structures, blanketing the stapes, if in its region, and seriously interfering with hearing. On inflation they often bag out into the canal in single or multiple bosses and may furnish strikingly variable pictures as shown in Figs. 1927 and 1929. So complete may be the depression of a scar that it may be practically unseen, its peripheral portions hiding beneath the perforation-margins, while its center, instead of being concave and giving back the usual reflection, may apply itself to the convex promontory and seem but a glossy coating of its surface (Figs. 1930 and 1931). The perforation may therefore seem still open; but inflation will usually distend its cicatrix conspicuously in front of the drumhead. Such flaccid scars often interfere with the hearing. Multiple incisions have therefore been made in the hope of effecting a firmer cicatrization; but I have

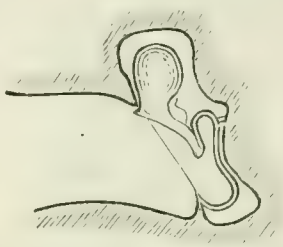

FIG. 1930.—Diagrammatic Section of a Large Free Cicatrix Depressed into Contact with the Inner Tympanic Wall and Stretched in all Directions, so that the Margins of the Perforations Overhang it.

FIG. 1931.—A Large Reniform Perforation of the Left Membrana Tympani, in a Man Twenty-one Years of Age, is Closed by a Delicate, almost Invisible Cicatrix Closely Applied to the Underlying Structures. The niche of the round window posteriorly, and the incudo-stapedial joint above, are seen as clearly as though not covered. The tube was but slightly permeable, and little functional improvement or change of the picture was afforded by inflation.

generally found that better results may be obtained from McKeown's plan of painting the distended drumhead with contractile collodion. The temporary splinting is accompanied by enough irritant effect to thicken up the flaccid tissues, and even though there is little visible difference, there is often much gain in hearing after a few repetitions.

Small scars, however much they may collapse, and provided they are not located directly over the stapes, rarely disturb the hearing so long as they remain free; but adhesion to the underlying structures, especially those of the inner wall (Fig. 1932), is usually very disabling to the conducting apparatus. Such attachment may be primary, in that the remains of the drumhead are united thus to the tympanic walls by granulations that should have built up a cicatricial closure of the perforation; but it may also be secondary to the collapse of a full-formed scar. Not very rarely vigorous inflation or pneumatic massage is seen to be followed by extravasations in a scar lifted from a contact that has given rise to inosculation of its vessels with those of the underlying tissues. Where the margins of the open perforation are bound down to inner structures, very puzzling pictures are sometimes presented; for we generally recognize a hole by its sharp-cut margins, and with the melting of these into other parts, landmarks may be wholly effaced. In very rare instances a free cicatrix may form in advance of parts thus bound down and such a condition of "detachment of the manubrium" results as is shown in Figs. 1933 and 1934.

Occasionally a complete new membrane may form external to the annulus, arising apparently from the union of granulations which spring from the canal-walls. Those which I have met were located in the inner third of the canal, at the upper part very close to the drumhead; but they were placed almost at a right angle to the axis of the canal, with none of the obliquity of the real drumhead. The usual landmarks of the drumhead were also lacking. As they probably impede hearing very little if at all and are excellent protective partitions for the drum-tissues, interference for their removal is rarely advisable.

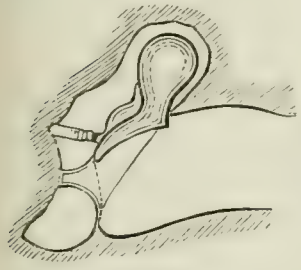

Fig. 1932.

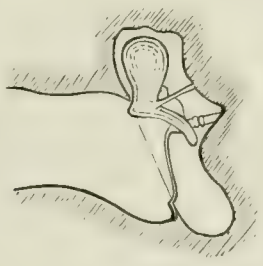

Fig. 1933.

Fig. 1932.—Diagrammatic Section of a Small Depressed Cicatrix Attached to the Promontory.

Fig. 4193.—Diagrammatic Section of the Same Case, Showing the Knee Below and the Manubrium Drawn in Behind the Middle of the Membrane.

Where healing of a perforation is long delayed and it seems advisable to secure the protective effect of an intact drumhead, this result may often be promoted by the surgeon, either through freshening the edges by rubbing or by stimulants such as silver or trichloracetic acid (twenty-five per cent.), or—more safely—by Blake's method of covering it with a patch of thin writing or tissue paper. This may be moistened so that it shall adhere by its own sizing, or it may be coated with a little boroglyceride or glycerin of tannin and carried by a probe or forceps into snug contact with the margins. In a week or two it may be washed away and replaced if the healing is incomplete; but a dry non-vitalized opening that has been rather widening than narrowing for weeks or months, will sometimes be found perfectly healed at the end of a week or ten days. The lining membrane of the egg-shell has also been used, but with doubtful advantage. In this delicate procedure full recognition of the obliquity of the drumhead is essential if precise placing of the patch is to be secured. It is also very important to warn the patient that a decided loss of hearing may be the primary result of such interference; for otherwise he may be greatly disturbed by this temporary change for the worse.

Perforations in the flaccid membrane show a much less marked tendency to close, and this is especially true of those cases in which there has been any caries of the adjacent margin of the scute. Some of this is ascribable to the ingrowing of epithelium and the formation of cholesteatoma within the attic and antrum. The rapidly proliferating epithelium (Blake has shown that the growth is most rapid above) transplanted to the succulent mucous surface, grows with unprecedented activity. Desquamation takes place promptly and finds the region unprepared to rid itself of the débris. These cavities are naturally lined with cells which break down into mucus and are supplied with cilia to sweep the fluid down the Eustachian tube; but the cilia, if not already destroyed, are incompetent to move the flakes of epidermis, and these remain to excite further the proliferating tendency. Onion-like masses are formed as layer is added to layer, and under pressure of the collection the bony walls may undergo absorption, the soft tissues stretch or yield, or, with the help of any infective material that may be present, a suppuration may be set up. This is likely only to swell the collection and painfully increase the destructive pressure. Fortunately, the outward direction often offers the least resistance, and through the old perforation or one new-formed, the pearly mass may escape into the canal; too frequently, however, it is only by absorption or carious destruction of the bony walls that an exit can be secured. The ossicles, if uninjured by the earlier suppuration, are apt to suffer displacement or caries, granulations form as the natural protest of the parts, and, as a result of their endeavor to rid themselves of the really foreign material, all the malign elements of chronic suppuration are called into activity. Strictly, the cholesteatoma should be called a *product*, not a neoplasm, although its analogy to the pearly nodule of epithelioma is very close; yet it acts at times almost as destructively as does a vascular growth and has a similar tendency to renew itself after removal. Absorption or carious destruction of the scute, or so much of it as forms the outer wall of the affected region, may afford adequate exit for the material so often as it forms, although the soft parts are apt to grow more or less over the gap and a parturition in miniature has to be suffered each time that a mass finds exit. In some cases, even without such opening up of the affected

Fig. 1934.—Right Membrana Tympani of a Woman, Aged Forty-five, with Long-standing Intermittent Suppuration of the Tympanum Recently Recurring. Small central perforation in a free cicatrix stretched across in front of the lower half of the manubrium. Periphery of membrane thickened and opaque, calcified anteriorly; the central portion depressed and presenting a sharp "kneeing" below. Closure of the perforation by drying of the scanty discharge leads to further depression of the cicatrix, and brings it into contact with the lower portion of the manubrium, which is then seen to be entire and perhaps bound down to the promontory. Before rupture the thin scar was visibly pulsating and gave way spontaneously under observation.

area, the proliferative tendency seems to wear itself out; but more often there is at best recurrent suppuration—"repeated gatherings" as the sufferer naturally calls them—if not a persistent discharge with exacerbations, until some serious accident occurs or the surgeon forestalls it by operation. No branch of surgery has made greater advance within the past active decades than has otology in dealing with these cholesteatomatous conditions and their results. It is a subject for most earnest congratulation that we are growing into a better comprehension of the pathological principles which underlie these cases; and while our diagnostic skill is increasingly efficient in bringing them to recognition and clearing the mystery which often enshrouded them, we are also more prompt and rational in combating them. For a long time to come, however, we may expect to see cases in which, owing to neglect (on the part of the patient rather than on that of the physician), these cholesteatomatous masses continue to exert their injurious effects unchecked. I have repeatedly seen the entire mastoid hollowed out into one huge cavity filled with such a laminated mass, with absorption or caries of the inner table and serious pressure on the dura and brain. Knuckle-like portions may invade the cranial cavity and give all the pressure-symptoms of brain-tumor, or the whole mass, with the pus which it has induced, may enter the cranial fossa as an extradural abscess and make its way outward through the squama. In this, or in one of many other ways, which will be set forth in detail in other articles of this group, cholesteatomatous masses may involve extensive portions of the temporal bone and set up a variety of pathological processes of the most serious character.

Caries of the ossicles is to be expected in many of these cases; in some of them, indeed, it may have already led to their dislocation or exfoliation before the patient is first seen. If the disease has not advanced so far as this it may often be stayed and the ossicular chain restored to usefulness or at least to innocuousness. It is often most surprising how perfect the hearing may be with the attic full of pus and the ossicles bare or clearly carious. The most vulnerable, because least vascularized, portion is the shank or descending process of the incus (Fig. 1897); and its destruction sets the stapes free of hindrance, as well as of help, from the rest of the ossicular chain. The neck of the malleus, where Prussak's pouch holds infective material in contact with it, is next in the frequency of its involvement; yet it may be eaten through and the head loosened or lost without great impairment of function. These and many other carious portions are after all almost microscopic in size, and operative interference on a very minute scale may prove adequate for securing resolution. Thus, for example, rubbing the bare surfaces with a bare or cotton-tipped probe may not only reveal but at the same time sufficiently curette the caries, and a speedy and lasting cure has frequently rewarded this procedure in my experience. Persistent polyps or granulations justify suspicion of the integrity of some portion of the bony structure, even when it wholly eludes careful probing; but painstaking, and if need be painsgiving, search and minutely thorough use of the measures elsewhere detailed will bring most of these cases to an apparent cure. This, however, should be regarded as a mere truce, and minute crusts should be searched for at intervals; and when found they are often best removed dry, so that we may see if the under surface is wet with recent discharge.

Fig. 1935.—Extensive Destruction of the Membrana Tympani, Partially Replaced by a Retracted and Plicated Cicatrix. The malleus-handle is greatly thickened and apparently truncated, with its short process covered with granulations. The incus seems to be lost and the stapes is exposed to view, covered by an almost invisible membrane through which its dimpled head shows perfectly. The promontory is rough, and there is a red streak posteriorly of uncertain nature.

When the ossicular chain is broken, as by loss of the incus or its shank, any remains of the damaged larger ossicles are of interest only as possible maintainers of suppuration, and if not soon brought to healing should be removed; but when the chain is unbroken, more can generally be accomplished for the improvement of the hearing by judicious mobilization and massage than by excision. Adhesions, after being cut, often unite more firmly than before; but the blunt probe may stretch them so as to afford lasting relief. When the dimpled head of the stapes comes to view (Fig. 1935) we know that the incus is disarticulated, if not lost, and we should confine our intervention to freeing the oval and round windows.

B. Alexander Randall.

**Ear, General Therapeutics of Diseases of the.**—In writing upon general aural therapeutics a practical division of the subject has seemed to me one of the great difficulties. That previous writers have experienced the same difficulty seems shown by the fact that scarcely two of them have written along parallel lines. Almost every one has divided this chapter in a different manner from all the others. At first it seemed to me as if the rational plan would be to take general symptomatology as a basis; the objection to this, however, is the fact that each symptom is, or may be, produced by many of the individual diseases, and that general therapy along this line would resolve itself more or less into a consideration of what could be done for these individual diseases, which seems without the scope of such a chapter as this one.

Considerable deliberation on the subject has resulted in the determination to pursue the following line of thought:

First. To consider briefly some prophylactic measures whereby those having sound ears may avoid and overcome conditions which are prone to originate ear diseases, and whereby those already the subject of such conditions, or already having some ear trouble, may take such precautions as will tend to prevent those conditions from growing worse.

Second. To take up the subject of local remedies, under which heading will be considered those procedures in more or less frequent use, such as blood-letting, heat, cold, inflation by the various methods, massage, electricity, etc., and to assign to them in a general way their various values and uses; and finally,

Third. To consider very briefly general remedies—*i.e.* the treatment of the ear by means of constitutional measures.

I. Prophylaxis.—"To prevent disease is better than to cure disease" has become a trite saying, and to-day, more than ever before, do we very properly follow out the principles of prophylaxis, both in general medicine and in our own limited specialty of otology. Much can be accomplished in many cases by the carrying out of simple, yet important, hygienic measures, in other cases through a practical and timely resort to medication or to operative procedures.

In order to a wise prevention a moment's consideration must be given to the manner in which the ear becomes involved as a result of general or local disease elsewhere. We know that under normal conditions, and in perfect health, we carry about in our mouths a large number of pathogenic germs, whose possibilities for harm are beyond question. We remain in health so long as the normal protective factors retain their functional activity; but when they suffer injury, then these pathogenic factors become capable of harm to the health. One of the most important factors in protection—a factor which varies in efficiency

according to the locality—is the unbroken continuity of the epithelial layer; another is the fact that some germs and their products are antagonistic to others.

Inflammatory processes in the ear may develop from within and also from without. By far the most frequent point of origin is the nasopharynx. Given a "cold" or a surface chill, a congestion of the nasopharyngeal mucous membrane is sure to develop, and soon thereafter there will be a decrease or cessation of the ciliary activity of the tubal epithelium; and with this will be associated an interference with the normal ventilation of the tympanic cavity, which is thereby rendered much more accessible to pathogenic germs.

From without arise injuries and inflammatory processes of the auricle and external canal which may extend from there to the parotid region, the side of the neck, or the mastoid process, or which may set up some general disease, *e.g.* erysipelas, or may reach the tympanic cavity. These paths, or methods, of infection point the way for prophylaxis, or for treatment in the early stages.

Preventive measures should begin then with the nasopharynx, and first of all may be mentioned some of the simple means that should be employed when a condition of health exists. An important matter is the hygiene of the mouth and nasopharynx, where may at any time be found a list of germs that is already astoundingly large, but is still growing. The care of the teeth, even among those who give them care, is, as a rule, insufficient; they should at least be thoroughly cleansed on retiring and on rising; I believe, too, with Dio Lewis, in the proper use of the toothpick after each meal, and, if this is supplemented by a mouthful of water forced rapidly to and fro between the teeth to wash out as far as possible any remaining fragments of food, certainly the condition of most mouths would be much improved. Gargling may also, in my judgment, be made a more valuable cleansing means than is ordinarily the case. The noisy process with which we are most familiar accomplishes but little, the fluid employed not reaching as a rule beyond the anterior faucial pillars.

The following procedure, described by Haug, is, I believe, much better: "Take a medium-sized mouthful of some good antiseptic mouth wash, throw the head partially, not too far, backward, allow the fluid to run by gravity slowly and quietly downward until the reflex irritation causes a contraction of the muscles of deglutition, when the head is thrown slightly forward, and the contents expelled through the mouth." By this means certainly the tonsils and much of the pharynx, possibly also some of the nasopharynx, are influenced by the cleansing process.

In acute catarrhal inflammation of the nasopharynx and nose, whether in the form of a simple angina or as a symptom of measles, scarlatina, etc., the middle ear is threatened; and here we may properly say a word or two in relation to the various procedures which may compress the air in the nasopharynx, and as to which prophylaxis requires a warning. First of all, as regards blowing the nose—a homely subject, but one of decided importance. So far as is possible this should be avoided during the first few days of such an acute coryza, and when it must be done, let it be done with both nostrils open, and as gently as possible; for, as a matter of fact, it accomplishes but little good, whereas the tendency is distinctly toward an increase of the congestion, which in turn increases the desire to again blow the nose. Again, snuffs which cause sneezing are, as a rule, irritating, and sneezing itself, especially if it be a person's habit more or less to suppress it, may forcibly open the Eustachian tubes with bad results. Adopting the same line of reasoning we should say a word against the use—certainly the general and indiscriminate use, without previous cleansing of the nose and nasopharynx—of the various therapeutic measures (Valsalva, Politzer bag, and Eustachian catheter) which cause compression of the air in the nasopharynx and tympanic cavity. This precaution is advisable, not only so long as the acute nasopharyngeal irritation remains, but also during the continuance of pain and deafness in the ear, with exudate in the tympanic cavity. The danger to be feared is that fluid, and with it the agents of infection, may be forced back into the mastoid antrum and cells.

During many of the acute illnesses of infants and children, or even of adults, especially if attended by symptoms not easily accounted for—*e.g.* elevation of temperature, coma, gastrointestinal disturbances, etc. —a daily inspection of the tympanic membranes may wisely be made, so that, if occasion arises, prompt incision may be made, and thereby certain dangers and unnecessary destruction of tissues be avoided.

In the case of people, whether children or adults, who are the subjects of frequently recurring or chronic so-called colds or catarrhs, the hearing is at all times more or less threatened. The cause of such catarrhal manifestations needs to be carefully looked for and removed, and consists usually in some form of nasal obstruction or intranasal pressure, or in a more or less complete vasomotor paralysis of the nasal and nasopharyngeal mucosa due to a gastrointestinal, or other, autotoxemia, and upon this causative factor I wish to place a special emphasis. Under this general designation comes adenoid hypertrophy, by far the most important single item to be mentioned under the heading of "prophylaxis of ear diseases." The presence of these lymphoid masses must be looked upon as a distinct threat to the hearing not only of children, but of adults as well, even those who may not necessarily in childhood have had the ear symptoms attributable to adenoids. I say this because I am thoroughly convinced of the need, from the aurist's standpoint, for removal of adenoids when present in any considerable amount, even though the ear symptoms at the time be slight or nil. The faucial tonsils, while not exerting by any means the same harmful influence upon the ears as does the enlarged third tonsil, may still, when much enlarged, and especially if the seat of frequently recurring acute inflammatory attacks, do considerable harm. They should therefore be removed, both in the interest of the ears and in that of the general health.

The nasal douche, when considered from the viewpoint of the ear, must receive our unqualified condemnation, since by no means infrequently, even when used with much care, it is the source of violent middle-ear and mastoid inflammations.

Inflammations of the auricle, external canal, and middle ear, arising from external causes, are many of them capable of easy prevention. Eczema, erysipelas, tumors, inoculation tuberculosis, and abscesses of the lobule, are all of them conditions which may, and do, arise from piercing the lobe of the ear for the wearing of earrings, and may all of them, therefore, be prevented if people can be reasoned, or shamed, out of that form of vanity which is especially an inheritance from our heathen ancestry.

Improper methods of cleansing the external canal are accountable for many ear troubles, *e.g.* for simple impaction of cerumen, for localized and diffuse inflammations of the canal walls, and even for serious middle-ear troubles, all of which are largely or entirely preventable. I refer to the various ear spoons, of wood, hard rubber, ivory, or metal, ear sponges, penholders, toothpicks, matches, hairpins, the twisting of a corner of a towel into shape for use as a boring machine, etc. I would include here also the frequent syringing of healthy ears, and the senseless use of oily and other drops, such, *e.g.* as are applied to the ear for the relief of toothache. All the evils attending these various manipulations may be avoided if we, the members of the medical profession, will instruct our patients that wax is a normal secretion, that an all-wise Providence has provided natural methods for its removal, and that, finally, ears in health can be

cleansed, and *should* be cleansed, by means of a moist cloth stretched over the end of one of the larger fingers.

The danger of injury to the ear as a result of foreign bodies in the external auditory canal is so slight, and that due to unwise and unskilful efforts to remove them is so great, that I cannot avoid the mention of the one means—a suitable syringe and warm water—whereby a very large proportion of foreign bodies can be harmlessly removed, and would condemn the almost universal early resort to forceps and such injury-working measures.

The principles underlying prophylaxis impel me also to say a word relative to another condition, often simple in itself, viz., traumatic perforation of the tympanic membrane. A majority of such cases, if left alone—the canal being gently wiped out with cotton moistened with some antiseptic, and then plugged with a little sterile cotton—recover without serious results: while, on the other hand, they may be seriously complicated by even such seemingly harmless measures as syringing, etc.

The general question of sea-bathing seems of sufficient importance to warrant us in devoting a few lines to its consideration. For this purpose it is necessary to divide people into two large classes—those who have, and those who have not, a perforation of the tympanic membrane. In the former class sea-bathing is attended with very considerable danger, because in them the harm arises through the water reaching the middle ear by way of the external auditory canal; for this class the safe course is to avoid sea-bathing, unless the utmost precaution is taken against "getting water in the ear." This danger can be warded off to a large extent, although not entirely, by tightly plugging the affected ear with "non-absorbent" cotton. In the second class, injury, when it arises, is due to the water reaching the tympanic cavity through the nose or mouth, the nasopharynx, and the Eustachian tube. The danger to this class is far less than to those with perforated membranes, but that danger exists is shown by the very considerable increase of acute middle-ear affections which is observed during each bathing season. However, the risk is, on the whole, so slight that, offsetting against it the benefit to be gained, we cannot in a general way advise against sea-bathing.

II. Local Remedies.—1. *Blood-letting.*—Local blood-letting is of use almost exclusively in acute inflammatory processes of either the external or the middle ear, and especially in their early stages. Its effect in such cases is, as a general rule, amelioration, in a fair proportion cessation, of the pain. In the chronic hyperemias not much effect is to be looked for. The abstraction of blood is usually accomplished by means of either the natural or the artificial leech. The number of the former used varies from about one to three in young children to three to six in adults. When the inflammation is located in the external canal, membrana tympani, or tympanic cavity, the leech should be placed close in front of the tragus. The surface of the mastoid should be selected in case of inflammation within that process. When the application of leeches is left to the patient's own management, it is advisable to mark with ink the exact spots upon which it is desired that they be placed. At the same time provision should be made for rendering the skin of this region, before the leeches are applied, as nearly as possible aseptic. The canal is also to be closed with cotton, and careful directions should be given as to how the after-bleeding may be controlled. For the latter purpose the following measures will be found useful: Apply a pledget of absorbent cotton to the wound, and keep up pressure upon it for several minutes, apply styptic in the place of absorbent cotton; or finally, make pressure by means of adhesive plaster or by an application of iodoform collodion. Whatever material may have been used, it should not be removed for several hours after the bleeding ceases.

The field of usefulness of the artificial leech is somewhat limited, owing to the frequent tenderness existing at the spot where it would naturally be placed. Its special advantages are, that it can be had and used in localities where the natural leech is not procurable, and that in the shortest possible time a considerable quantity of blood can be removed.

The quantity of blood to be taken will of course depend upon the needs of the case; from thirty to one hundred grams being the usual limits. The time when the blood should be abstracted seems to be of some importance; Schwartze's rule is to do the operation in the evening and then to insist on absolute rest and quiet the following day. If after a second abstraction of blood relief is not obtained, other measures should be employed. Scarification of the canal walls has been much used, and is recommended as an efficacious means of blood-letting in inflammation of the soft parts of the canal. Of all the forms of artificial leech, Bacon's is perhaps the most practical. Resort to blood-letting is, however, much less frequent now, especially by aurists, than was the case even ten years ago, owing to the masking of symptoms, and the frequent superficial infections caused thereby.

2. *Heat and Cold.*—(*a*) *Heat.* From time immemorial heat in some form or other has been a much-used means of quieting pain in the ear. As a home remedy it has been applied in almost every conceivable way, and to the charge of having used heat in many objectionable forms the medical profession too must plead guilty. Heat has been applied to the ear in the form of a roasted onion, of flaxseed and bread-and-milk poultices, of warm oil, glycerin, or vaseline, of warm milk, and even of warm urine, etc.; and among the objectionable ways of using heat I would include the introduction of hot sweet oil and laudanum, hot almond oil, hot cocaine solutions, etc., which are still extensively recommended by druggists and others. At present we speak of using heat in either the moist or the dry form. As sources of dry heat may be mentioned the hot-water bag, a hot brick, an electric-light bulb, a "Japanese stove," Leiter's coil, etc. Moist heat too may be used in various ways: the hot water ear bath of von Troeltsch, consisting of the frequent filling of the external canal with hot water from a spoon; the ear douche from a special apparatus or from a fountain syringe, or Fayette's ear douche, by means of which a constant stream of continually renewed water of proper temperature flows through the canal and over the face of the membrana tympani.

It is my belief that most, if not all, of the virtue claimed for the various forms of ear drops in relieving earache is due to the fact that they are put in the ear warm. If this be so, then more virtue can be obtained from hot water, because with it a nearly continuous heat can be secured, with the additional advantage that, when we cease using it, the ear after simple drying is left clean. As between dry and moist heat, it is generally believed that moist heat rather favors suppuration; therefore, if in a given case it is thought that suppuration may still be avoided, the choice should favor dry heat.

(*b*) *Cold.* The use of cold as an antiphlogistic measure in inflammatory ear affections is of much more recent date, and, even before the general prejudice against cold in these conditions has been entirely overcome, already the pendulum of professional opinion is beginning to swing back toward heat as the preferable measure. During recent years, however, cold has been much used, especially for the pain accompanying acute mastoid involvement. It can be conveniently employed by allowing a continuous stream of ice-cold water to flow through a Leiter's coil surrounding the ear; or by means of the aural ice-bag; or in accordance with the plan of Winternitz for bringing about a contraction of the carotid artery, by the use, in the an-

tero-lateral region of the neck, of a cold compress or its equivalent, whereby, it is asserted, the temperature in the external auditory canal can be distinctly lowered. To sum up, as to heat and cold: in pain due to inflammations of the external canal and of the tympanic cavity, heat is almost universally approved—in the moist form, when it is desired to favor suppuration, in the dry, in cases in which there is still a chance of avoiding it. When the mastoid process is involved, heat and cold both have their adherents, while some are beginning to oppose both because of the fact that they may obscure a condition already in many cases difficult of recognition. All agree, however, that if either heat or cold is employed in this class of cases, it should not as a rule be used for more than from twenty-four to forty-eight hours.

Fig. 1936.—All-rubber Ear Syringe.

3. *Syringing the Ear.*—Under this heading may be considered both syringing of the external auditory canal, and syringing of the tympanic cavity—the latter, either through a tympanic cavity cannula, or, more rarely, through the Eustachian tube. The immediate purpose of all ear syringing is to remove either foreign bodies or pathological secretions. It may also, however, prove to be directly curative of the pathological processes themselves; *i.e.* while it removes the foreign bodies or the impacted cerumen, it cures at the same time the associate inflammatory disturbance. Syringing, however, is commonly employed as the first preparatory step in an examination of the ear or in instituting treatment.

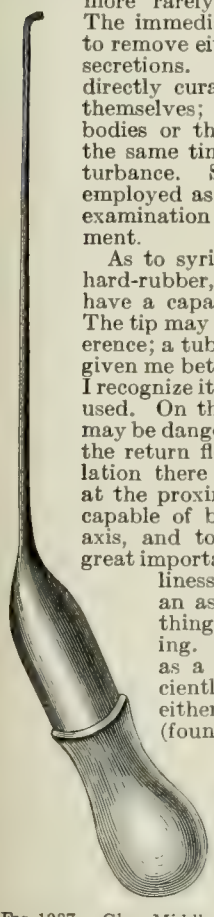

Fig. 1937.—Glass Middle-ear Pipette.

As to syringes, they may be constructed of hard-rubber, metal, or glass. They should have a capacity of from two to four ounces. The tip may vary according to individual preference; a tubular tip with an angular bend has given me better results than any other, though I recognize its possibilities for harm if carelessly used. On the other hand, an olive-shaped tip may be dangerous through its interference with the return flow. For convenience of manipulation there should be attached to the barrel, at the proximal end of the syringe, two rings capable of being revolved about the central axis, and to the plunger, one ring. It is of great importance, from the view-point of cleanliness, to have the syringe fitted with an asbestos plunger, so that the whole thing can be regularly sterilized by boiling. For use by the patient, although as a rule patients use no syringe efficiently, probably the best and safest is either an irrigator or aural douche (fountain syringe), or a hard-rubber syringe of one-ounce capacity; for children perhaps the all-soft rubber ball and tip (Fig. 1936) will answer the purpose best.

Water that has been sterilized by boiling, and cooled to a temperature of from 100° to 115° F. (the best general rule is to use it as hot as the patient can comfortably bear it), is the best fluid to use in the syringe or douche. If desired, and especially if the solution is for use in the tympanic cavity, boric acid may be added to the point of saturation, or table salt to the extent of a 0.75-per-cent. solution. The temperature is important, since if the fluid used is too cool, very disagreeable symptoms may result, such as vertigo, nausea, vomiting, syncope, and even prolonged unconsciousness. The same symptoms may develop if too much force is used, the rule being to begin with the least possible force and gradually to increase until the object of the syringing is accomplished, provided threatening symptoms do not sooner develop. At the same time the canal should be straightened with the left hand, and the thumb and index finger should be used as a support for the nozzle end of the syringe, in order that all danger of injuring the canal walls may be avoided.

For washing out the tympanic cavity through a perforation in the drum membrane, specially bent tips attached directly to a small syringe, or to a bulb syringe, or to a simple rubber cap (Fig. 1937), are useful. Of these the best and most generally used is that known as Hartmann's tympanic-cavity cannula (see Fig. 1938).

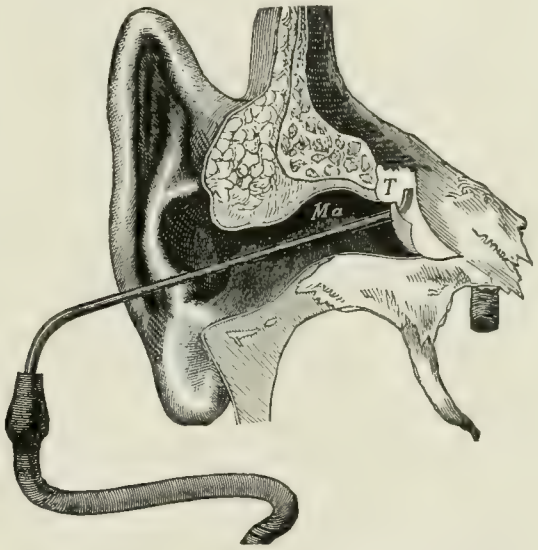


Fig. 1938.—Diagram Showing Hartmann's Cannula in Position.

Syringing of the tympanic cavity through the Eustachian tube is not much resorted to in this country. It presupposes, as a matter of course, a free exit for the liquid used through a perforation in the membrana tympani, and requires a catheter, fitted at one end to the syringe, and fitting at the other end rather snugly into the mouth of the Eustachian tube. It seems to me a rare occasion indeed when all that this method will accomplish cannot be more easily and better done in some other way. This criticism applies with even greater force to the method of Saemann and Gruber, by whom it is recommended that, in some cases of perforation of both membranes, the ear be syringed out by means of Politzer's method of inflation, with the single difference that the air bag, instead of being filled with air, be filled with water of a suitable temperature.

4. *Drying the Ear.*—This seems to me a therapeutic measure of sufficient importance, and one that is so often wrongly carried out, or not carried out at all, as to warrant us in speaking of it under a separate heading. In all cases in which an ear is syringed, or in which secretion is present, whether in the external canal or in the tympanic cavity, and especially if any medication is to be applied, thorough drying is an essential factor in successful treatment. The reason for this is evident: the amount of medicament that can come into contact with any particular portion of the skin of the canal or mucosa of the tympanum is at

best small; if this be diluted at the point of contact by ever so little water or secretion, the strength of our application becomes at once an unknown quantity.

This drying may be best accomplished by means of absorbent cotton and a cotton carrier; the *small* pledgets of cotton being applied under a good illumination of the parts. The pledgets used at the termination of this drying process should be so small as to pass through the perforation of the membrane, and absorb and remove the moisture from within the tympanic cavity. For the same reason I believe that patients should have impressed upon them the importance of drying the ear as a part of the home treatment, and I find that, as a rule, they can be taught to accomplish this with a fair degree of success by means of small pledgets of cotton rolled together between the thumb and finger of one hand to such a consistence as to hold their shape and reach nearly or quite to the bottom of the external auditory canal—beyond this of course a patient cannot safely go.

5. *Compression and Rarefaction of Air.*—(*a*) *Air Compression.*—The influence of the air douche is first of all mechanical. In the next place, by opening the Eustachian tube it ventilates the tympanic cavity, and makes pressure on its walls, especially on the membrana tympani, pushing it outward, and with it the ossicular chain, thus tending to rectify a position of the membrane which is pathological, and to lessen the fixation of these parts. The same pressure is exerted upon the movable parts of the labyrinth walls—the two fenestræ, thus more or less affecting the intralabyrinthine pressure. As a further effect of the procedure, there may be, and probably is, some slight tendency on the part of the air current to catch up small portions of mucus, germs included, and force them from the nasopharynx and Eustachian tube into the tympanic cavity.

Upon the tympanum the effect is dependent upon the presence or absence of a perforation in the tympanic membrane. If a perforation exists, secretion is pushed through it into the external canal. If there is no perforation, it is still possible that a portion of the secretion, if not too thick and if the head be held in a proper position, may be forced out through the Eustachian tube and thus escape into the nasopharynx. More usually, however, the air and secretion become mixed up and spread out in a thin layer over much of the surface of the tympanum. The further influence produced by the changes in the air pressure upon the circulation and the lymph stream seems to require a word, since, according to Kessel, the lymph vessels in the tympanic mucosa show round or sac-like enlargements, and stand in open communication with the tympanic cavity. If this be true, then pressure upon the mucous membrane should cause a movement of the contents of the lymph vessels in the natural direction. With the lessening of the pressure the lymph spaces are refilled from the tympanic cavity, and in this way a sort of suction is produced which must effectively aid the absorption of the mechanically broken-up and spread-out secretion. However this may be, experience proves that the tympanic cavity can be emptied of its contained secretion either by absorption or by its escape through the Eustachian tube in a greater or lesser degree, in a fair proportion of cases, by the use of the air douche.

The therapeutic effect to be obtained from Politzer's method of inflation seems much more limited than that from the Eustachian catheter, and to be attended with rather more risk of harm. The former would seem to find its legitimate use especially in children with tubal catarrh, as a temporary expedient until the condition is removed by proper attention to the cause, and possibly in cases with perforation of both tympanic membranes, when it is desired to empty the cavities of secretion, although to accomplish this purpose, whether the secretion be purulent or catarrhal, with an already existing perforation, or immediately after incision of the membrane, it is my very strong preference to force the secretion *from* the tympanic cavity, *through* the Eustachian tube, *into* the nasopharynx, by means of Siegle's otoscope and a column of compressed air in the external auditory canal, this method being to my mind more certain, less disagreeable to the patient, and more in accord with the anatomy and physiology of the Eustachian tube, the ciliæ of whose mucosa move toward, and not away from, the nasopharynx, and favor therefore drainage in that direction. Catheterization, on the other hand, would seem to be the better method when the desire is for the ventilation of one ear only, and in the chronic cases.

(*b*) *Rarefaction of the Air.*—This procedure has been used in the external auditory canal to affect the membrana tympani and ossicles, as well as to influence the intralabyrinthine pressure; it has also been much recommended for the removal of secretion from the middle ear. When the membrane is intact it may be used through the Eustachian tube, but in the case of a perforation it should be employed through the external canal. To get the desired effect in the canal the simplest means consists of a piece of rubber tubing armed at one end with a tip which tightly fits the meatus, and at the other with a mouth-piece through which suction is applied. The same principle is involved whether the suction be made by an empty rubber bag, as with Siegle's otoscope, or with the Delstanche *rarefacteur*. A word of caution as to all these methods is necessary, since if rarefaction is too vigorously applied, the result may be a rupture of the vessels with ecchymosis, or even rupture of the membrana tympani itself. The therapeutic effect most frequently obtained is a lessening or cessation, for a longer or shorter time, of tinnitus, a lighter feeling in the ear and head, and less often a gain in hearing.

The most frequent manner of using this principle for the removal of secretion from the tympanic cavity through the Eustachian tube, corresponds in a general way with the process for inflating the ear, with the difference that the air bag, supplying the suction power, is applied to the catheter empty instead of full, the effect being more or less enhanced by placing the head at the same time in such a position as to favor the escape of fluid through the tube. This method of necessity presupposes that the secretion is thin, and in suitable cases the procedure is oftentimes attended by appreciable results.

6. *The Use of the Eustachian Bougie.*—Opinion has varied greatly in regard to the use of the Eustachian bougie. Many have claimed excellent results from its use, while some have put their very positive stamp of disapproval upon it, as an instrument capable of doing much harm. While it must be admitted that, if carelessly or unskilfully used, serious injury may result, can this not be said with equal truth of all good measures whether medical or surgical? For myself, I am sure that much good can be accomplished with the Eustachian bougie, especially in cases in which tinnitus and deafness are in a measure due to stenosis of the tube. The ordinary celluloid bougie answers well the purpose.

A closely allied therapeutic measure is that which is based upon the use of the metallic (gold) bougie, or electrode. This consists really of the bougie plus electrolysis, and some authorities claim that much more good is to be obtained from this procedure than from the use of the bougie alone, especially in those cases in which the strictures are dense and tight. The use of the bougie for massage of the isthmus tubæ will be spoken of under massage.

7. *Massage.*—The application of massage to the organ of hearing may be accomplished in various ways, and various parts of the ear may be thus treated. In the first place, going from without inward, may be mentioned that form of massage which was first described by Gerst, then elaborated by Zaufal, and finally warmly recommended by Schwartze. In this form

the massage is applied *to the region around the auricle*, and is said to have its greatest value in promoting the absorption of secretion from the tympanic cavity in acute middle-ear catarrh. Zaufal's description of the method follows: "The patient sits with bared breast, and head inclined to the opposite side, on a low stool. The masseur stands behind the patient; both hands, well anointed with vaseline, are laid flat, one on the mastoid process, the other on the parotid region, so that the index finger of one presses upon the root of the sternomastoid muscle, the other on the anterior edge of the tragus; then rub downward, at first lightly, then with increasing pressure, to the level of the shoulder, so that the pressure of the index fingers is exerted especially in the groove between the ramus of the jaw and the head of the muscle, as well as upon the vessel furrow below." He recommends daily three sittings of three minutes each, or two of five minutes; and that in acute processes it should be deferred until the fever has disappeared.

Secondly, massage of the membrana tympani and ossicles, applied by some one of the various methods, may be used directly or indirectly. In case of its indirect application the cylinder of air in the external auditory canal is used as a medium for alternate rarefaction and compression. "Tragus pressure," as recommended by Hammell, may be mentioned first on account of its great simplicity. By rapid to-and-fro pressure on, and releasing of, the tragus, the air in the canal is thereby alternately compressed and rarefied, thus causing more or less motion of the membrana tympani and ossicles. The procedure is to be carried out by the patient from four to six times daily, each time for a minute or a minute and a half, and at the rate of from 120 to 150 times per minute. Although this method is frequently recommended by a number of aurists, I cannot say that I have ever seen much benefit from its use.

The same principle, it seems to me, can be much more effectively carried out by means of Siegle's otoscope, Delstanche's *masseur*, or some similar apparatus. In a certain proportion of cases the tinnitus is certainly somewhat relieved, at least temporarily and less often the hearing manifests some improvement. In a somewhat similar manner the massaging force has been applied by means of more or less powerful sound vibrations, as produced by the vibrophone, vibrometer, etc. I mention these procedures, however, only to condemn them.

Direct application of massage to the membrane and ossicles may be accomplished by means of the flexible pressure probe of Lucæ, applied to the short process of the malleus, or by the mechanical vibrators of Lester Freudenthal, and others. My experience with the so-called mechanical massage is, I must confess, limited, but it has been sufficient to force upon me the conclusion that its use is not likely to be very extensive on account of the marked tympanic congestion which results, as well as on account of the pain experienced by the patient.

*Intratympanic massage* seems to me to be well worthy of mention here. For its accomplishment it is necessary that a more or less rapidly interrupted stream of compressed air, cold, warm, or medicated, should be conducted through the Eustachian catheter and tube against the inner surface of the membrana tympani. Its use is naturally limited to a great extent to the treatment of chronic middle-ear catarrhal conditions.

Finally, *massage of the isthmus tubæ* has been recommended by Urbantschitsch and more or less used by many of us. It is carried out as follows: a probe-pointed bougie (celluloid) is pushed through the Eustachian tube to the isthmus, and then rapidly (from 150 to 250 times per minute) moved in and out, first in the bony, then in the membranous portion. Begin with a session lasting a half-minute, and gradually increase the length of time of the sitting to three or even five minutes, with short pauses. The special indication for the employment of this method is to be found in the tubal swelling which accompanies chronic middle-ear catarrh, in which cases it should do more good than simple dilatation, the benefit manifesting itself by better hearing and less tinnitus.

8. *Local Medication.*—This may be applied: (1) to the region around the ear; (2) by way of the external auditory canal; (3) by way of the Eustachian tube.

(1) *The application of drugs to the region around the ear* is limited almost entirely to (*a*) sedatives, in the form of salves or liniments, and (b) counterirritants, mostly applied to the mastoid region. The power of either for good must of necessity be slight, while the use of the latter in certain acute mastoid affections may be positively harmful through the masking of symptoms which at best are not always easy to determine.

(2) *Medication by way of the external auditory canal* is of much value, because a direct therapeutic effect can be obtained upon the disease processes of the canal and membrana tympani, and, if the latter is perforated or a sinus exists, upon the more or less distant parts of the tympanic cavity. Liquids, powders, or solids may be used. Of great importance for the successful employment of this mode of treatment is the previous thorough removal of all secretions, etc., which, by covering the parts, by diluting the medicament, or through chemical combination, may limit the effect of the drug. All fluid applications should be warmed, and should be introduced by means of a pipette or spoon, the head being inclined to the opposite side and the external canal straightened; after which, by appropriate pressure on the tragus, the fluid can be forced further into the canal, into the tympanic cavity, or even all the way through the Eustachian tube into the nasopharynx. A prolonged effect may be obtained by saturating a pledget of cotton and placing it in contact with the affected part.

Medication of the external and middle ears by means of powders has been, and is, a much-abused method. If the material is finely pulverized, or triturated, and used in small quantities, excellent results are often obtained in cases having a fairly large perforation in the tympanic membrane. For the introduction of powders into the ear various powder blowers have been devised, of which the one shown in Fig. 1939 gives excellent satisfaction. For use

Fig. 1939.—Davidson's "Powder Blower," with End-pieces of Two Different Sizes.

by the patient a glass tube, with an attachment of rubber tubing and a mouthpiece, answers a good purpose.

Caustics—such as chromic acid and nitrate of silver (fused on the end of a slender probe)—are applied through the external canal. In using them it is of great importance to the patient's comfort that *only* the desired spot be touched, and that too only after thorough cleansing and drying. Under this heading may be mentioned a special form of local treatment, that of aural suppositories or bougies, of medicated gelatin, as suggested by Gruber; these are introduced into the ear by means of forceps, and then afterward the canal is closed with cotton.

(3) In case of an intact membrana tympani fluids and vapors may be introduced into the tympanic cavity *through the Eustachian tube*. Only small quantities (from eight to ten drops) should be used at a time, and only after being warmed. After the catheter is in position, introduce into it with a syringe

or pipette the requisite amount of the fluid to be used, and then with the air bag blow it with some force into the tympanic cavity, always using the diagnostic tube for information as to the successful carrying out of the maneuver. The entry of the fluid into the tympanum may be facilitated by having the patient swallow at the moment of emptying the air bag, by having the head well inclined toward the side to be medicated, and by using a catheter which enters well into the mouth of the tube. Steam, plain or medicated, formerly much used in the treatment of middle-ear catarrhs, has now largely given place to volatile medicaments (chloroform, chloride of ethyl, menthol, etc.), or to some of the vaporized or nebulized oils containing various substances in solution. By using some one of the well-equipped nebulizing apparatuses the fine vapors can be thrown, warm, into the tympanic cavity through the catheter, with rapid interruptions, so as to obtain a three-fold effect, viz., that of the medicated oils, that of the heat, and that of the pneumatic massage acting upon the inner surface of the membrane and the ossicles. While the injection of fluids into the tympanum is certainly less in vogue than formerly, still with caution, especially as to the fluids used, it sometimes accomplishes beneficial results, mostly for tinnitus, when other means fail.

9. *Electricity.*—The general aural therapeutics of electricity furnishes a good illustration of how great an absence of unanimity there may be in the profession relative to a given subject. While as regards the value of electricity in diagnosis and prognosis there seem to be a few who think alike, when it comes to the question of therapeutics there exists the most astonishing divergence of opinion. It is true that there are competent observers who claim good results from the treatment of the ear by galvanism, faradism, static electricity, and cataphoresis. It is also true that equally good observers have utterly failed by the same methods to obtain similar results. In a general way, as the result of a moderate amount of experimenting, I am compelled to cast in my lot with the latter class. At the same time the effort to bring order out of what is at present a state of semi-chaos, is a fascinating one. I believe that much good thought and considerable time are being given to the subject, and that the time is not far distant when those who are prosecuting these studies will be able to give to the medical world some greater uniformity of thought in regard to this matter than now exists.

It does seem in some measure settled that there are cases of tinnitus which are benefited, and even cured, by both the constant and the interrupted current. This appears to be especially true of those cases in which a morbid state (either torpidity or hyperesthesia) of the auditory nerve exists. It is also easy to believe, what seems to be pretty well proven, that electrolysis is useful in the treatment of strictures of the Eustachian tube, as well as in connective-tissue strictures of the external auditory canal. The use of the galvanocautery in the external and middle ears, although it has been highly recommended, seems to me to present no advantages over other methods, and to be fraught with greater possibilities for harm.

In the present uncertainty as to the value of electricity in aural therapeutics, it seems to me better to refer any one wishing to investigate the subject, to treatises and articles in which the general and special methods of application can be more exhaustively handled than would be possible in the present article.

III. General Remedies.—It is self-evident that general conditions are often of the utmost significance in local disease; that ear diseases may both cause and arise from constitutional disturbances, and that the cure of the former may be greatly hindered unless our therapeutic efforts take into account not only the local disease, but the general bodily health as well. Suppose, for example, a disease of the ear has for its underlying cause tuberculosis, anemia, disturbances of nutrition, etc.; the best results can be obtained only by using all the therapeutic procedures, medicinal, hygienic, dietetic, etc., which medical science offers for the cure of these conditions. The following should receive careful attention: the climatic conditions; the condition of the dwelling-place; the choice of bedrooms; the proper ventilation of the house; the suitableness of the clothing. A general tendency to take colds must be combated; the condition of the general circulation is an important factor; outdoor exercise may have to be urged; the school life of children often needs regulation; tobacco and alcohol will need to be limited or stopped; and, finally, the evil effects of late suppers, venereal excesses, masturbation, etc., must all be done away with. Changes of climate from cold to warm, and vice versa, or from the seashore to the mountains, often accomplish, especially among children, what local treatment utterly fails to effect. Patients who show a tendency to frequently recurring stubborn middle-ear catarrhs, as well as those who are subject to the milder transient catarrhal attacks, need a stimulation of the superficial circulation, together with a more complete elimination of some of the by-products of imperfect digestion (autotoxemia). Such patients may often be benefited by baths, saline, hot and cold, Russian, Turkish, etc., plus a proper dietary.

Treatment of ear diseases by internal medication, formerly almost the exclusive treatment, still has its uses. For example, purgation in acute ear processes, especially in persons of full habit, after bloodletting is of practical use, as it is also in chronic passive hyperemic conditions of the ear. Pilocarpine, which is so effective in inducing sweating, may also afford material aid to local treatment, in cases of acute and chronic middle-ear catarrh, by favoring the absorption of exudates or as yet unorganized inflammatory products in the internal ear. A kind of specific action has been ascribed to the use of quinine, in the manner recommended by Charcot, in Ménière's group of symptoms. I wish to express my disapproval of what seems to me the far too frequent use of narcotics, antineuralgics, and antipyretics, in affections of the ear, believing, as I do, that the occasions are very rare when greater relief cannot be obtained by safer and less objectionable measures.

Suggestion and hypnosis have been recommended for the cure of hysterical deafness, and Urbantschitsch claims to have achieved success with it in the relief of tinnitus as well as deafness. Other writers also have published good results from its use. Nevertheless, great caution must be urged upon those who contemplate dealing with remedies such as these.

Concerning the treatment of the suppurative ear conditions and their complications with the vaccines, autogenous or polyvalent, the various sera, the bacterines, leucocytic extract, etc., it is impossible at the present time to speak with authority, since even the advocates of their use are as yet too far from arriving at anything like a uniformity of opinion concerning either their action or their dosage.

J. E. Sheppard.

**Ear: Intracranial Complications of Otitis Media.**—The majority of brain affections of otitic origin result from the neglect of chronic suppurative otitis media. Less often is the cranial cavity invaded during the acute stage of purulent otitis. It is important to remember, therefore, that every case of persistent or recurring suppuration of the middle ear is a menace to life and, while no one can say in what particular instances such an otitis will prove dangerous, the possibility of its causing in-

tracranial complications must always be borne in mind. A purulent inflammation of the middle ear may persist for many years without causing serious disturbance to health yet there is no moment in all these years when it may not flare up into an active process that will be extremely difficult to check or control. The influence of climatic changes, the introduction of fresh infection, or the occurrence of some debilitating systemic affection, are some of the things that may excite a dangerous exacerbation of the otitic disease.

The active agent in the production of the intracranial complications of suppurative otitis media is almost always the same pathogenic microorganism that is present in the infected ear and the most prominent among these are *Streptococcus pyogenes aureus, Streptococcus mucosus capsulatus,* the *Staphylococcus pyogenes aureus* and the pneumococcus. From the tympanic cavity and the mastoid antrum the inflammatory process readily spreads through the cellular structure of the temporal bone and the histological character of this osseous framework probably determines in a large measure the direction in which the necrosis will further advance. Should the bony roof of the tympanum or of the antrum be very thin or of cellular structure, while the general mastoid process is of the diploetic or eburnated type, conditions favor erosion into the cerebral cavity in this direction. On the other hand, should the thin-walled cellular spaces of the mastoid invite extension of the necrosis posteriorly, conditions are favorable for invasion of the cerebellar cavity in the region of the sigmoid sinus. Extension of the necrotic process through the inner wall of the tympanum, by way of the oval or round window, or, less frequently, through the semicircular canals or the cochlea, occasionally takes place, producing first an inflammation of the labyrinth and then intracranial disturbance by extension through the ducts of the vestibule or cochlea or by way of the porus acusticus internus.

The intracranial disease originates, in most cases, at the point where the infection from the ear penetrates the cranium; consequently, when the invasion is through the roof of the tympanum or mastoid antrum it is the cerebrum, and when through the middle wall of the mastoid or the labyrinth it is the cerebellum that is attacked. Conversely, it may be said that a middle-ear suppuration that appears to be most active in the tympanum is favorable to the production of extradural abscess, meningitis, or cerebral abscess; and that those cases of purulent otitis which show more marked involvement of the mastoid region, as evidenced by greater tenderness at the tip or along the posterior border of the mastoid process, are prone to produce perisinous abscess, lateral sinus thrombosis, or cerebellar abscess.

Brain lesions resulting from acute suppurative otitis media usually follow so closely upon the onset of a primary disease that the relationship between the two is quite apparent. The earache probably did not, as is usual in uncomplicated cases, cease with the rupture of the tympanic membrane and the outpouring of purulent secretion from the tympanum; the febrile condition persisted; the general malaise incident to a continued illness increased; and the symptoms appeared in sequence indicative of a complicating extension, according to the portion of the brain attacked.

But the majority of all the intracranial affections result from chronic purulent otitis media of a destructive type, and in these cases certain symptoms are common to all. Thus, very many patients, at the time when the surgeon is consulted, give the following clinical history: An otorrhea, possibly originating in an attack of one or other of the exanthematous fevers, had existed for a long period of time but the patient had become so accustomed to the discharge that it gave him no concern. Suddenly, as a result of reinfection possibly, symptoms of acute inflammation arose. There was pain in the ear and over the temporal region, accompanied by a general febrile condition. The mastoid region became tender to the touch and its covering tissues were edematous. The discharge from the ear may have increased in amount, or have changed in character, or have ceased entirely. From this point onward the symptoms observed vary according to the route traversed by the suppurative process and also according to the nature and extent of the tissues attacked. The occurrence of a sharp chill is strongly suggestive of intracranial invasion, but does not point solely to any particular one of the different pathological conditions that are encountered within the cranium and which we shall now consider separately.

The intracranial infections of otitic origin manifest themselves as pachymeningitis and extradural abscess, leptomeningitis, brain abscess, and lateral sinus thrombosis.

Pachymeningitis and Extradural Abscess.—Perforating erosion of the superior or median wall of the mastoid process is usually the result of chronic, slowly progressing infection and nature has abundant opportunity to prepare her resistance. As advancing necrosis is always preceded by a zone of inflamed and infiltrated tissue, irritation of the adjacent dura has led to the formation on its surface of a plastic exudate by the time perforation of the bone is completed. By fibrous organization of this exudate the dura becomes adherent to the healthy bone beyond the area of necrosis and the affected portion of the dura is recognized as a limited *external pachymeningitis.* If, now, pus collects under the dura, in this circumscribed, walled-off area, it constitutes an *extradural abscess.* Such a localized inflammation forming about the lateral sinus is called a *perisinous pachymeningitis* or *abscess.* Pachymeningitis and extradural abscess, including the perisinous variety, is the most frequent of the intracranial complications of otitis media. It is often associated with one or more of the other intracranial infections, however, especially with lateral sinus thrombosis.

*Symptoms.*—In the majority of cases the development of the disease is insidious and marked by no symptoms whatever that can be distinguished from those of infection of the ear or mastoid, the pachymeningitis being discovered on removal of the carious inner wall of the mastoid or of the carious tympanic or antral roof. Generally, the symptoms noted will be simply those of an aggravated mastoiditis: marked pain behind and deep in the ear, possibly with waves of pain radiating over the temporal region; tenderness on pressure over the mastoid process, extending, sometimes, above and in front of the auricle along the temporal ridge; a chill or chilly sensations may announce irruption of the disease into the cranial cavity and this symptom is especially suggestive of irritation of the dural covering of the sinus. A diffuse and severe headache is almost always present when there is a large collection of pus under the dura. The temperature and leucocyte count range about the same as in simple mastoiditis.

*Prognosis and Treatment.*—The prognosis is good if proper treatment be instituted while the disease is limited to the external layer of the dura. Invasion of the arachnopia or infection of the blood stream of the sinus increases the gravity of the situation. Treatment consists in the prompt performance of a thorough mastoidectomy. It is the duty of the surgeon in every mastoid operation, but particularly when operating upon a case where the symptoms have been of a severe or aggravated character, carefully to explore the roof of the tympanum and antrum and the cells bordering upon the sigmoid portion of the lateral sinus. Any fistulous tract or suspicious cell must be followed up with the curette and every par-

ticle of pus, granulation tissue, or apparently unhealthy bone should be removed until the parts present a clean appearance. Since extradural collections of pus may be found where least expected, successful treatment depends upon thorough exploration and cleansing of the operative field in every mastoidectomy.

Leptomeningitis is of much more serious import than inflammation limited to the external layer of the brain covering, the web-like composition of the arachnoid and the great vascularity of the pia mater being conducive to a rapid spread of the infection. In many instances of otitic origin it is the closing scene in cases of brain abscess, pachymeningitis or sinus thrombosis, but, quite as frequently the direct route of invasion cannot be positively traced and the infective material has probably reached the arachnopia through or along the course of the small communicating vessels.

*Symptoms and Diagnosis.*—Following upon the symptoms of middle-ear disease and mastoiditis, the earliest symptoms are apt to be those of irritation of the meninges. These are insomnia, headache, vertigo, nausea, hyperesthesia of the nerves of sense, stiffness of the muscles of the neck and irregular pupillary action. Inasmuch, however, as headache, sleeplessness, dizziness, and nausea are so frequently observed in uncomplicated cases of mastoiditis and may so readily be otherwise explained in many instances when they are the result of meningeal irritation, their true importance is easily overlooked entirely or considerably discounted in the early stage of meningitis. Paralytic symptoms, such as dilatation of the pupils, paralysis of the external muscles of the eyes, and facial nerve paresis are strong evidences of meningitis but they do not occur until the disease is well advanced. Optic neuritis is also a late symptom, because it arises from increased intracranial pressure, and one for which the patient cannot afford to wait before having proper treatment instituted. Kernig's sign (inability to extend the knee while the leg is held flexed in the sitting posture) is a fairly constant early symptom and should be sought for in every suspected case.

Among the earliest reliable symptoms are the high temperature, marked leucocytosis—with a relatively high polymorphonuclear percentage—and the altered character of the cerebrospinal fluid. The characteristic temperature chart of leptomeningitis shows a continuous high fever; there may be variations between the morning and evening readings but they are not so marked as those which are associated with infection of the blood stream. The leucocytic count is generally much higher than in simple mastoiditis and usually higher than that observed in either sinus thrombosis or brain abscess. Differential count shows a polymorphonuclear percentage of from eighty to ninety per cent. The most positive information is gained, though, from a study of the fluid obtained by spinal puncture. Since the normal spinal fluid is absolutely clear and free from all cellular elements and fibrin, the slightest cloudiness present at the time when the fluid is withdrawn, and caused by the presence of cells, or the formation of fibrin in the fluid after it has stood for several hours, are pathognomonic of an inflammatory exudation in the meninges. It has also been suggested recently that certain chemical tests of the cerebrospinal fluid in suspected cases may enable one to make the diagnosis even earlier than is possible by waiting for the presence therein of tissue cells or bacteria. The normal cerebrospinal fluid is slightly alkaline or neutral and contains some copper-reducing substance, possibly a dextrose. It is claimed that there is a diminished alkalinity or actual acidity of the fluid and a disappearance of its copper-reducing substance, in the very earliest stage of purulent meningitis. (Kopetzky, Tr. IX. Internat. Otological Congress, p. 329). If these chemical tests should prove to be of the value indicated, they will be of the greatest importance because the successful treatment of this affection depends principally upon the possibility of making an early diagnosis.

The clinical signs of a more advanced stage of meningitis are extreme restlessness and irritability, delirium, convulsions, and retraction of the head with rigidity of the neck muscles. In children this last symptom often reaches a degree of marked opisthotonos. Paralysis of the third, fourth or sixth nerves may be partial or complete and swelling of the optic papilla with engorgement of the retinal vessels is sometimes observed ophthalmoscopically. All of these lesions are the result of increased intracranial pressure and are, consequently, not seen until the disease is far advanced. Coma and Cheyne-Stokes respiration point to approaching dissolution.

*Prognosis and Treatment.*—The prognosis in leptomeningitis is very grave and it is generally recognized as the most dangerous of the otitic brain complications. That it is not utterly hopeless is proven by the fact that a small percentage of recoveries have been reported as following operative intervention in what appeared to be desperate cases. Medication has little curative value in this disease. Applications of ice to the head and the administration of morphine for relief of the pain promote the patient's comfort. Purgation, to overcome a constipation that is sometimes very obstinate, may be indicated. The liberal administration of urotropin in suspicious cases, pending a definite diagnosis, may be advisable but should not be depended upon to the neglect of proper surgical measures. In the early stage of the inflammation, while the exudate is still of a serous character, lumbar puncture may prove beneficial by removing some of the infective material and this little operation may be repeated if it produces manifest improvement in the patient's condition. If the appropriate specific antitoxic serum can be obtained it should be employed and may be injected subcutaneously or into the spinal canal after withdrawal of cerebrospinal fluid.

The surgical measure most urgently demanded in otitic meningitis is, primarily, eradication of the middle-ear disease, with subsequent exposure and examination of the meninges. In the course of the mastoidectomy a careful search should be made for any carious tract leading into the cranium, and, if a fistula should be found in the tegmen, the tympanic or antral bony roof must be removed to a sufficient extent to afford a satisfactory view of the base of the brain. Incision of the dura at that point is quite proper if it is evidently diseased, but, on the other hand, if this portion of the dura is apparently healthy, it is perhaps wiser to leave it intact and to make a second opening into the cranium directly above the external auditory meatus, through the squamous portion of the temporal bone, and to open the dura over the convex surface of the cerebrum; this avoids direct connection of healthy brain tissue with a region known to be infected. A gauze drain may be inserted through the incised dura into the intradural spaces, whether the exudate be serous or purulent. If the inflammation be limited to the base of the brain, removal of the underlying aural focus and drainage through the incision in the dura give a fair hope of recovery but if the convex surface of the hemisphere is extensively involved even drainage is not very promising. The surgical problem is largely a mechanical one and Haynes (Tr. IX. Internat. Otological Congress, p. 355) has recently proposed a new operation which has for its principal object the securing of efficient drainage of the infected cerebrospinal fluid from the cisterna magna. The operation has not yet been tried sufficiently often to predict its probable value.

Brain abscess results much more commonly from neglected chronic than acute suppurative otitis media

and usually the abscess is connected directly with the suppurating ear, either lying in contact with the diseased bone or situated within the brain at a short distance therefrom and connected with the latter by a fistulous tract. The seat of the abscess is largely dependent upon the pathway of infection. When the latter travels by direct contiguity through the roof of the tympanum or antrum the abscess locates in the third temporosphenoidal convolution; when it extends along the vessels the abscess may be in other portions of the cerebrum; when it extends by contiguity through the inner wall of the mastoid process the abscess will be in the lateral lobe of the cerebellum; and when the continuity of extension is through the labyrinthine cavities the collection of pus will be found in the extreme portion of the cerebellum close to the acqueductus vestibuli or the meatus internus. The gray cortical substance of the brain seems to be more resistant to infection than the underlying white matter, so that, in the majority of instances the abscess lies in this deeper structure. The channel by which the infection has travelled from the necrotic bone through the dura and gray matter may become obliterated after establishment of the abscess and the new-formed tissue along this tract, sometimes cord-like in appearance, is called the stalk of the abscess. In the indirect method of formation a brain abscess may result from metastases from the tympanum or mastoid cells, the intervening bone and meningeal tissues remaining perfectly healthy. For instance, an arteriole may convey infective material and, depositing it in the form of an embolus at its terminal, provide a focus from which an abscess develops; or a vein traversing the region may become infected and a local necrosis and abscess formation follow this thrombophlebitis. In the slowly progressive chronic cases an investing membrane may develop, completely encapsulating the abscess and causing it to remain in a latent state for an indefinite period of time. Multiple abscesses are not uncommon and occasionally no connection between them can be demonstrated.

*Symptoms and Diagnosis.*—The most characteristic evidences of a brain abscess are: severe headache, drowsiness or sluggish cerebration, and projectile vomiting associated with moderate fever and slow pulse. The earliest symptoms to be noted are those relating to cerebral irritation. In the second stage may be grouped both the general and focal symptoms of increased intracranial pressure. To the third stage belong the manifestations of pressure plus toxemia. The headache is not different in character or degree from that accompanying the other intracranial complications of otitis but it is sometimes associated with a tenderness on percussion over a definite area; as the majority of abscesses are in the temporosphenoidal lobe and not far from the surface, this tenderness is apt to be found about an inch above and slightly posterior to the external auditory meatus.

The pulse rate is abnormally low in brain abscess and the change from normal is out of proportion to that of the temperature. Unless associated with meningitis, the temperature is likewise low and may be frequently marked by subnormal drops; the occurrence of subnormal temperatures in the evening is especially significant of brain abscess. Vomiting is one of the most constantly observed symptoms and may appear even in the initial stage. It differs from that induced by gastric disturbance in that it is not usually preceded by nausea but the vomitus is ejected forcibly and without warning. The leucocytosis is high, as is also the differential polymorphonuclear count.

As the disease advances the symptoms of the first stage are all exaggerated and evidences of pressure become more marked. A slow, sluggish cerebration is an important sign; convulsions are not uncommon in young patients and a mildly comatose condition is evident in most cases. Optic neuritis is an important sign of intracranial pressure and should be watched for with great care. Irregularity of action and slow response of the pupils to light point strongly to irritation of the brain.

Since cerebral abscess resulting from middle-ear disease is generally found in the temporosphenoidal lobe and more frequently on the right than the left side, localizing symptoms will not be ascertainable in the majority of cases. The characteristic disturbances from involvement of the left temporal lobe are word deafness and defective speech. The most commonly observed types of aphasia are: sensory aphasia—inability to understand the meaning of written or spoken words; amnesic aphasia—inability to remember words; and, paraphasia—where the patient miscalls objects and substitutes wrong words. Efforts at exact localization from these alterations in the function of hearing have not yet been productive of very great practical results.

All of the general symptoms given apply equally as well to the cerebellar as to the cerebral form of the disease. Tenderness over the occiput instead of over the temporal region, naturally leads one to suspect a focus in the cerebellum. Torticollis, vertigo, nystagmus, muscular weakness, and especially muscular incoordination point suggestively to the cerebellum as the site of disease.

Increase in the gravity of all the preceding symptoms, deep coma, and Cheyne-Stokes respiration usually mark the approaching fatal end but death may be sudden from rupture of the abscess into the lateral ventricle.

*Prognosis and Treatment.*—The prognosis of brain abscess is favorable only in those cases that are recognized early and treated promptly. Surgical intervention offers the only reasonable hope of preserving life and should be applied at the earliest possible moment. Under such treatment the prognosis has steadily improved in recent years. Aseptic operative technique has made it safe to enter the cranial cavity and the percentage of such successful operations should increase in the near future. The primary object of the operation should be a search for that spot where the infection penetrated the skull. This is best attained by a complete obliteration of the purulent disease of the tympanum and mastoid cells and a careful examination for fistulous tracts leading into the cerebrum or cerebellum. When such an infective pathway is discovered it is comparatively easy to follow it and supply drainage from the abscess. Failing to trace a direct connection between the aural disease and the suspected brain abscess, an exploration through the squamous portion of the temporal bone above the middle ear, or through the occipital bone posterior to the lateral sinus, becomes necessary.

LATERAL SINUS THROMBOSIS is, next to extradural abscess, the most frequent intracranial complication of suppurative otitis media. The sigmoid portion of the sinus is the most common site of invasion, the purulent process passing from the tympanum and antrum through the mastoidal cellular structure and eroding the median wall, but, not infrequently, especially in children, the infection spreads through the floor of the tympanum into the bulb of the jugular vein. A perisinous abscess first forms and then a phlebitis results from attack upon the dural covering of the vessel. When the vessel becomes inflamed, its intimal cells are soon infiltrated and become irregular in outline or even undergo desquamation, so that the smoothness normally presented to the blood stream is destroyed. At such a point clotting may readily commence and as the inflammation is bacterial in origin the thrombus quickly becomes an infected one. If a large area of the vessel wall is diseased the thrombus may have a considerable surface for adherence and its attachment spreads along the course of the vessel. So long as a channel for the stream is main-

tained the thrombotic mass is known as a lateral or incomplete thrombus; a thrombus becomes complete only when the lumen of the vessel is entirely obliterated. Suppuration, disintegration, and dissemination of the thrombus, with the production of general septicemia, by passage of the infective material through the jugular vein into the general circulation, is the logical consequence unless the process can be quickly arrested. Systemic infection is far more serious than the local effects of suppurative thrombosis.

In the very beginning, during the stage of phlebitis, the clot is probably always sterile and if the mastoid disease and perisinous collection of pus can be removed it is presumable that the thrombus, even if complete, may remain uninfected. Organization of the clot and recanalization of the vessel is experimentally possible and there are clinical experiences which indicate that such a process of recovery sometimes takes place in nature, but such experiences must be of extremely rare occurrence. When nature's local resisting powers fail and pyogenic destruction of the thrombus begins, disintegration of the mass is a matter that may well occasion alarm. The blood then becomes charged with myriads of microorganisms, infective emboli are transported by the general circulation to distant parts of the body, and septicemia with metastatic abscesses results.

*Symptoms and Diagnosis.*—Generally, a patient suspected of having this disease presents the previous history and clinical picture accepted as diagnostic of mastoiditis, some of the symptoms possibly being of an exaggerated character and occasioning the query as to possible invasion of the sinus. The leucocytosis and the polymorphonuclear count are usually much higher when the sinus is involved than when a simple mastoiditis exists. Hemicrania is usually present. Tenderness in the upper part of the posterior cervical triangle and along the course of the mastoid emissary vein is very suggestive. The diagnosis in this first stage is not easily and positively made prior to operation upon the mastoid cells. The occurrence of a chill or of chilly sensations in a patient suffering with mastoiditis should make one suspicious of sinus phlebitis and if this be followed by sudden and marked rise of temperature the diagnosis is almost sure. Following this, the most characteristic feature is the marked fluctuations of temperature that occur, the range being anywhere from normal to 103° or more. One should not wait, however, for this characteristic zigzagging temperature curve, which indicates disintegration of the thrombus and general septicemia, but should endeavor to recognize the onset of phlebitis and formation of the clot because the best results are to be obtained by early treatment. In doubtful cases bacteriological investigation of the blood must be made and a positive bacteriemia demands immediate operation. It is at present questionable whether this symptom can in the majority of cases be found sufficiently early to be of any great assistance in making an early diagnosis; if possible, we must learn to diagnose the condition before invasion of the blood stream has taken place.

*Prognosis and Treatment.*—The prognosis will be favorable just in proportion to the early period at which the diagnosis can be made and measures instituted for the prevention or removal of the clot. If contamination of the blood stream can be prevented a fair prospect for recovery exists. Even after disintegration has commenced, however, the prognosis is still favorable provided the local disease can be obliterated and a barrier interposed to the further infection of the general circulation. The latter object is accomplished by ligation of the internal jugular vein and statistics show that this measure is of the very greatest importance in reducing the mortality of the disease.

There can be no debate over different forms of treatment in this affection. The instant the diagnosis is made, preparation should begin for operation. The condition brooks no delay; surgical intervention is imperative. The most favorable time for removal of the thrombus is before its disintegration and dissemination have begun, and as the decomposition of an infected blood clot is a swift affair, the surgeon should intervene with celerity in order to prevent the graver consequences of infection. That a clear field of operation may be secured, the whole sinus wall should be exposed from the knee down to the jugular bulb. Every precaution must be taken to avoid wounding the vessel's coat while removing its bony covering, and every visible particle of necrotic bone and septic material should be cleaned out of the mastoid process before the vein is opened. Furthermore, it is wise, as a rule, to ligate the internal jugular vein before attempting to break up the thrombus occupying the sinus. One can never be absolutely certain about the bacteriological condition of the thrombus; it is presumably infected.

To open the sinus and attempt removal of the thrombus piecemeal with the jugular venous channel patent affords the opportunity, at least, for an embolus to be passed on to the central circulation. The portion of clot below the starting-point may look innocent and yet be very dangerous. To leave the jugular plugged at its bulbous portion by a clot of doubtful character is certainly risky. Ligation of the internal is a comparatively simple operation that can be easily and quickly performed and it adds scarcely any calculable risk to the main operation, while the sense of security which comes of knowledge that the main pathway of general infection is obstructed is invaluable.

Having ligated the vein, the mastoid wound may again be uncovered and the sinus opened. Incision should be made in the long axis of the vessel and the clot removed. Undue hemorrhage following this procedure can be readily checked and controlled by pressure with pledgets of gauze on the vessel wall.

H. O. Reik.

**Ear: Mastoid.**—See *Mastoid Operation.*

**Ear, Syphilis of the.**—Auricle.—*Primary syphilitic chancres* have been but very seldom seen on the auricle and the adjacent parts. Desprès[1] found among twelve hundred syphilitic patients one with a chancre (soft) on the auricle. Pellizzari[2] reports having seen a primary sore on the lobule, and thinks that it was caused by the use of a towel which the son of this patient had previously used in cleaning a sore on his penis. Hermet[3] saw a chancre on the lobule of a woman's ear, which resulted from a kiss by her infected husband. The same author[4] saw also, in the clinic of Dr. Fournier in Paris, a phagedenic hard chancre on the lobe and the posterior part of the lower third of the auricle, caused by the bite from an infected individual. A similar case, due to a bite, has been observed also by Hutchinson.[5] Hulot[6] saw a chancre on the base of the tragus, the origin of which was problematical. Zucker[7] has described at length the history of a case of chancre on the outer surface of the tragus. A chancre on the mastoid process in a man, due to the kiss of a prostitute, has been observed by Mracek,[8] and another in the same place in a child, caused by infection from the nurse, has been described by Hulot.[6] Finally, Lincke,[9] speaking of otitis syphilitica externa, says that it attacks sometimes the auricle, at other times the external canal, or it may attack both parts simultaneously, and that it manifests itself usually in the form of a chancre.

As far as can be seen from the description of the cases here cited, the chancres presented the usual appearance; the lymphatic glands in the vicinity were enlarged and indurated. In Zucker's case the

tragus was of a livid red color, of twice the normal thickness, and on its anterior surface was a pigmented radiating cicatrix. The entire parotid region was involved in the process; it was greatly swollen, felt as hard as a board, but was not at all painful. There was no secretion from the external canal, and the hearing was but slightly diminished in acuteness. In this case the diagnosis of primary syphilitic infection was facilitated by the recent appearance, on the surface of each hand, of three or four small, round, slightly scaly efflorescences. The genitals were intact, and the inguinal glands were not swollen. A course of inunctions produced a perfect and rapid cure.

A primary sore on the auricle may be mistaken for cancer, from which it differs, however, in that it presents a clean surface and secretes but little. The nearest lymphatic glands usually enlarge with the development of induration in the primary sore.

*Secondary and Tertiary Forms.*—Manifestations of constitutional syphilis are not very rarely observed in the auricle. Squamous, pustular, and papular eruptions, usually in connection with the same affection on the integument of adjacent parts, but sometimes limited to the auricle and external canal, have been seen by many writers. According to Gruber,[10] papular eruptions are most frequently seated at the point of insertion of the auricle, while exanthematous eruptions appear mostly on the other parts of the auricle. Broad condylomata have been often seen by Desprès on the lobule, and usually in the hole for the earring. Wilde,[11] as far as I know, is the only author who maintains that syphilitic ulceration is by no means uncommon, and that rupia is frequently seated on the external ear.

Tubercular syphilides and gummata of the auricle have been observed by Zeissl,[13] Burnett,[14] Buck,[15] Field,[20] Hessler,[17] Pelletan,[17] Sexton,[18] Pierce,[19] Ravogli,[20] Woakes,[21] Barklay,[22] Bumstead and Taylor,[23] McBride,[24] and Packard.[65] In all of the cases reported, the affections appeared in the so-called tertiary stage of syphilis. In almost all only one ear was affected, and in the majority of the cases no other symptom of syphilis was present at the time the patient came under observation. The seat of the tubercle or gumma was in the anterior part of the auricle in all the cases, except Burnett's, in which it occupied the posterior surface. A case with symmetrical patches of lupus erythematosus in the concha of each ear, probably syphilitic, was seen by Hutchinson (*loc. cit.*, p. 348). According to Zeissl, the auricle may be the seat of both the dry (non-ulcerating) and the ulcerating forms of gummata, and the latter frequently shows a tendency to the lupoid character in this situation (Fournier). In Burnett's case, which is about the only one recorded in which the disease was seen in its earliest stages, there first appeared a circumscribed infiltrated lump on the posterior surface of the auricle, and this gradually extended until it had diffused itself throughout the tissue of the pinna. It was slightly elevated above the general surface of the auricle, of a deep reddish color, painless, and was not attended with itching; it was inclined to run a slow course. In the space of a month or six weeks the infiltration had diffused itself throughout the greater part of the auricle, and somewhat over the mastoid portion. The thickening and deformity of the auricle had become considerable, the groove behind the auricle was obliterated, and the appendages assumed a firm, thick feeling. This condition lasted for some weeks, then softening and ulceration ensued, the latter beginning in some natural groove or depression. The ulcer thus formed by the breaking down of the gumma may assume any shape, and if not properly treated soon increases in size and depth. The floor of the ulcer is usually ragged and covered with dirty grayish matter which cannot be readily removed. The discharge from the ulcer is often excessively offensive. In several of the reported cases, necrosis of parts of the auricular cartilage and exfoliation of the sequestra occurred, and in Field's case two-thirds of the auricle was destroyed. As a rule, comparatively little deformity seems to result from this affection, sometimes even when the infiltration is extensive and the ulcer large and deep; very often an indelible, depressed white scar is in after years the only evidence remaining of the gumma. In Barklay's case, in which the cartilage of the concha, tragus, and canal was exfoliated, the general outline of the ear remained normal. The first abnormality to strike the attention was the peculiar deformity of the concha, the upper and lower limits of which were preserved, while the tragus and meatus were absent. The beginning of the helix above was at an oval pit in the concha, and the intertragal notch below was a circular pit. There was a shining, bulging, yellowish spot—resembling somewhat a sebaceous cyst—right over the site of the normal meatus, upon a strong band of cicatricial tissue, extending downward and backward from a spot above and in front of the site of the normal tragus, which band completely closed the meatus. Except a slight tightening of the skin, a seeming loss of subcutaneous tissue on the anterior side, and a slight drawing outward and forward of the auricle, it was otherwise apparently normal. Above and anterior to the site of the normal tragus, and near that of the temporomaxillary articulation, was a stellate cicatrix.

Packard's case[65] was that of a negro twenty-five years of age. A painful swelling, fluctuating on pressure, developed in the upper portion of the auricle twelve years after the primary sore. There was no history of injury. Under treatment the auricle attained its normal condition, except for the presence of some hardening and thickening of the cartilage, in a month.

The *diagnosis* of the diseases under consideration, as well as of those which I shall treat farther on, must rest largely on the previous history of the case. If syphilitic infection is denied, and necrosis of, or gummata on, the bones are absent, careful search should be made for scars and marks left by secondary affections of the skin and mucous membranes. An ulcerated tubercle may possibly be confounded with lupus vulgaris and scrofulous ulcer. In both of the last-named affections there is, however, very frequently considerable redness and edema of the skin around the ulcer, while the syphilitic ulcer is, in most instances, sharply bounded by healthy-looking skin. Lupus vulgaris begins, moreover, usually before puberty; its course is much more chronic, and there is but little discharge from the ulcer.

From an ulcerating epithelioma the syphilitic ulcer can generally be distinguished by the absence of enlarged glands in the neighborhood, and by the more offensive odor of the discharge.

The *treatment* of these affections does not differ from that of tertiary manifestations in other parts of the body. Iodide of potassium, alone or combined with mercury, will cure these cases.

Local treatment alone was of no avail in any one of the cases reported.

External Auditory Canal.—This part of the ear is not very rarely the seat of *Broad Condylomata* (*mucous warts*) and of ulcers in persons suffering from constitutional syphilis. The occurrence of the condylomata of the external canal is mentioned by Moos and by Troeltsch; but for the first full description of this affection and its treatment we are indebted to Stöhr,[25] who had the opportunity of seeing fourteen cases of this disease in about three years. Wilde's (*loc. cit.*, 222) case, published nearly twenty years before Stöhr's paper appeared, may, as Knapp suggests, have been also one of syphilitic origin; but Wilde, who throughout his book shows that he was familiar with the manifestations of syphilis in the ear, says

expressly that the patient was otherwise healthy, and attributed her affection to cold.

Since Stöhr's publication broad condylomata have been observed and described by Buck,[15] Knapp,[26] Christinneck,[27] Noquet,[28] Zucker,[7] Purjesz,[29] Felici,[30] Trautmann,[31] Kochner.[32] Desprès[1] found among 1,200 syphilitic patients (980 of whom had condylomata in various places), 5 cases of condylomata of the external canal; while Ravogli was unable to find a single case of condylomata of the external canal in 144 syphilitic individuals (77 of these had condylomata in other parts of the body) whose ears he had examined. Buck saw but 2 cases in 3,976 ear patients; Knapp met with only 1 case in from 9,000 to 10,000 ear cases; Kipp records but 2 cases out of about sixteen thousand ear patients; and the writer in almost thirty years' work has never seen a single case. Analyzed with regard to the sex, the published cases show a preponderance among the females. In most cases but one ear was affected. As a rule, condylomata of the external canal appear early in constitutional syphilis, while other skin eruptions, ulcerated papulæ on the fauces, and glandular swellings are present. In most cases purulent inflammation of the middle ear, sometimes of long standing, precedes the development of the growth. Condylomata begin as broad, slightly reddish papulæ, the surface of which at first is dry, but soon becomes moist. The papulæ gradually grow in size, and when situated close to each other they coalesce into large patches. These are often subdivided by rhagades. In most cases the upper surface of the excrescence, which is at first smooth and somewhat convex, becomes ulcerated and secretes a seropurulent fluid, which often causes inflammation and ulceration of the adjacent parts free from these growths. If ulceration does not occur, the epidermis covering the excrescence becomes thickened, whitish, and granular. These growths often occur in great numbers in all parts of the canal, and may even be seated on the drum membrane. Sometimes they not only fill the canal, but also protrude out of the external meatus. The excrescences are at first painless, but after ulceration has occurred they often cause severe pain, which is increased by movement of the jaw. More or less impairment of hearing and tinnitus usually result from the obstruction of the canal, and occasionally a purulent inflammation of the middle ear is developed subsequent to the appearance of the warts.

The diagnosis of broad condylomata of the external canal can usually be made without difficulty, as manifestations of secondary syphilis are almost always present in other parts of the body at the same time.

The prognosis is favorable. Under constitutional antisyphilitic treatment and the local applications to be mentioned, the excrescences usually shrink rapidly, and eventually disappear entirely. Depressed cicatrices, destitute of hair, sometimes remain, but permanent contraction of the canal very rarely follows this affection.

Constitutional treatment alone will in most cases cause the condylomata to disappear. But if they occlude the canal and cause retention of the discharge from the tympanic cavity, they may be abscised or carefully cauterized with nitrate of silver in substance. Thorough cleansing of the canal with warm salt water and inflation of the middle ear should also be practised if suppuration of the middle ear is present. In some cases benefit was apparently derived from dusting iodoform or calomel on the excrescence, or washing the same with a one-per-cent. solution of nitrate of silver.

*Syphilitic ulcers* of the external canal seem to have been observed by some of the older writers, as Bell, in his work on Lues, speaks of deafness produced by a "scruffy" eruption, and sometimes ulceration of the external auditory passage, occurring as a consequence of that disease. Referring to this Wilde says: "But his description is not sufficiently accurate to be depended upon, and has not been confirmed by subsequent observers. No doubt, cutaneous syphilitic disease will extend by ordinary continuity of surface into the meatus, but as a special form I am unacquainted with it." Since Wilde's time such ulcers have, however, been frequently observed, and have been studied especially by Schwartze.[33] According to this author they are usually annular in form and covered by a dirty, grayish-white exudation. Their edges are usually greatly swollen, and may thus cause considerable diminution of the caliber of the canal. They were seated in the outer part of the canal up to the point of union of the cartilaginous and osseous portions, and were found in one or both ears. He saw these ulcers in ears with normal membranes and healthy middle ears, but in most cases they were associated with chronic purulent inflammation of the middle ear and perforation of the drum membrane. The glands in the vicinity of the ear were always much swollen in these cases, and other manifestations of constitutional disease were never wanting. Cases of this kind have been reported by Hinton,[34] Buck,[15] Politzer and Jacobson.[35]

*Diagnosis.*—Non-specific ulcers of the external canal are very rarely seen, except in children with neglected purulent inflammation of the middle ear, and in eczema of the canal in adults, and the presence of an ulcer should therefore always arouse suspicion as to the existence of constitutional syphilis. It seems hardly possible that the opening of a furuncle can be mistaken for ulcer by any one at all familiar with ear affections. In cases of syphilitic ulcer the glands near the ear are always swollen, and other signs of syphilis are never absent.

*Diffuse inflammation of the external canal* due to syphilis is said by Ladreit de Lacharrière to be of frequent occurrence in the secondary stage. According to this author both canals are usually attacked simultaneously; there is only moderate swelling; the skin is red and cracked, and the discharge is very offensive. But McBride[32] appears to be the only other author who has seen such a case, and in his there was no disagreeable odor. If we exclude the cases in which papulæ or condylomata are present, the secretion from which causes inflammation of the lining of the parts of the external canal free from them, instances of diffuse inflammation of this part are doubtless very rare in syphilitic persons. Kipp has seen but a single case of this kind, and this occurred many years after infection, and was associated with non-purulent inflammation of the middle ear, and caries of the superior maxillary and palate bones of the same side. In this case the walls of the osseous part of the canal were very red and somewhat swollen. The pain was very great, and not much relieved by repeated deep and long incisions, which at no time liberated pus. The walls were at no time covered by exudation, and there was but little secretion from them. The drum membrane was but little inflamed, and although it was repeatedly freely incised in the hope of giving exit to supposed pent-up secretion in the tympanic cavity, none escaped. The Eustachian tube was almost impermeable. After much and long-continued suffering the pain subsided eventually while the patient was taking iodide of potassium; complete deafness remained.

The characteristic symptom of syphilitic inflammation of the external canal is said to be very severe pain, even when the swelling is not very great, which is not relieved by the usual remedies, but yields at once to constitutional treatment (Schwabach).

*Exostoses of the external canal* may, according to Gruber, be caused by syphilis; but nearly all other writers deny that syphilis has anything whatever to do with the production of these growths.

The Drum Membrane.—This part of the ear appears to be but rarely the seat of syphilitic infiltration

and growths. Lang[36] observed a case in which there was a large, pale, glistening papule at the place of the short process of the hammer on a drum membrane; the membrane itself was very red in its anterior upper quadrant, and slightly opaque throughout. The patient was a woman, with early symptoms of constitutional syphilis.

Condylomata, as we have seen, have been found here in a few cases, in which these growths existed also on the walls of the canal.

Baratoux[37] has recorded the case of a woman in whom he found five small gummata on the cheek, in front of the ear; a sixth on the mastoid process; three in the concha and outer part of the external canal; a small egg-shaped, prominent, faintly opalescent, gummatous tumor on the lower posterior part of the drum membrane; and a small, round ulcer, covered with a yellowish-white, adherent substance, in front of the handle of the malleus.

The gumma on the drum membrane became ulcerated at its summit in a few days, while the ulcer was cicatrizing.

Middle Ear.—The diseases of the middle ear observed in individuals afflicted with constitutional syphilis do not differ essentially, in their objective and subjective symptoms, from the same diseases occurring in non-syphilitic subjects. Most writers are agreed, however, that the syphilitic forms are characterized by a marked tendency to implication of the labyrinth, or, to speak more precisely, by the appearance of symptoms commonly regarded as indicative of disease of the auditory nerve, at an unusually early period. The middle-ear disease may present itself in the form of an acute catarrhal inflammation, a chronic catarrhal inflammation, a purulent inflammation, or as a neuralgia of the tympanic cavity.

*Acute Catarrhal Inflammation.*—This disease is usually, but by no means always, associated with syphilitic disease of the nasopharyngeal cavity. Frequently but one ear is affected, and in such cases the disease of the pharynx is usually found to be confined to that side. Sometimes this consists of only a superficial erosion. In many cases the ulceration is confined to the posterior wall of the pharynx, behind the velum palati, and, as in this location it rarely causes the patient much inconvenience, it may be overlooked if an examination with the rhinoscopic mirror is omitted.

The *subjective and objective symptoms*, and the course of syphilitic acute catarrhal inflammation, resemble so closely the idiopathic form that a description of the same seems unnecessary in this place. Schwartze asserts that an impairment in the conduction of sound through the bones occurs regularly at an early period in this disease, and adds that it is not known to what this is due. The present writer has, however, seen a number of cases of this affection in which the bone conduction remained unimpaired throughout.

*Chronic Aural Catarrh.*—With regard to this disease, Wilde says: "All the cases I have seen of this affection occurred in young men, and generally those of fair complexion and blue eyes, who had had primary sores upon the genitals from six to twelve months previously, which sores were rather of a deceptive character, so that mercury was seldom given, in the first instance at least, in a legitimate form. Sore throat, papular eruptions, copper-colored blotches, fissures and ulcers of the tongue, with loss of strength and slight nocturnal pains, existed previous to the aural affections, which should, I think, be ranked as tertiary symptoms. In almost every case I have witnessed the disease appeared suddenly as an eruption was fading off; in two it came on at a later period and was accompanied by loss of hair; in most it appeared in the upper and middle ranks of life. In some cases there is at first a sensation of fulness in the head, and often vertigo upon stooping or rising up suddenly, but in no instance have I seen it accompanied by acute pain. Tinnitus is not always present." In all of the cases observed by Schwartze, except two, in which the patients positively stated that the disease began with lancinating pain, and in all seen by Kipp and the present writer of this article, the disease was insidious in its approach, and pain in the ear was absent throughout its course. Pain in the bones of the head was, however, occasionally complained of. Tinnitus was present in nearly all the cases, though it was not always very annoying.

As regards the appearance of the drum membrane Wilde says: "Upon inspection the amount of redness and vascularity will be found much greater than in subacute myringitis, and in this consists one of the chief characteristics of this disease, that while it is unaccompanied by local pain, the membrana tympani will be found to present an amount of redness equal to, and sometimes exceeding, that seen in acute myringitis.* The redness has generally, however, a brownish hue in the syphilitic form. There is not at first much loss of polish, but in a short time the membrane assumes a fuzzy appearance. Both ears are usually attacked at the same time." Schwartze (*op. cit.*, p. 264), Roosa, and most of the more recent writers on this subject, on the other hand, have been unable to find in the appearance of the drum membrane in this disease anything that could be regarded as pathognomonic of its syphilitic character. Pomeroy[61] believes that it very frequently does not differ in appearance from that in non-syphilitic disease, but that signs of infiltration of the membrane, giving it a greater degree of opacity than would result from a non-specific inflammation, will cause one to suspect constitutional disease. In his opinion the most important aid, however, to diagnosis is the history. Sturgis[69] regards the infiltration of the tympanum, conjoined with the absence of vascular congestion, as characteristic of syphilitic catarrh of the middle ear.

The Eustachian tube is usually easily permeable, at least by the aid of the catheter. The sounds heard on auscultation are usually dry and broad, but sometimes moist râles are heard. The inflation rarely improves the hearing even for a short time, though it sometimes temporarily arrests the tinnitus. The lining membrane of the pharynx is nearly always hyperemic, and very often superficial ulcers are found on the arches of the palate and the tonsils. The nose is usually not markedly diseased. The impairment of hearing, which is commonly already well advanced when the patient comes under treatment, in the majority of cases goes rapidly from bad to worse, so that in the course of a few months only loud speech can be heard close to the ear. In the remainder the progress is much slower, and instead of months years may pass before this state is reached. In a case seen by Schwartze a sudden and great increase in the hardness of hearing followed a blow on the head. In many of the cases, even in persons under thirty years of age, an impairment or loss of bone conduction occurs at an early stage of the disease when the tick of the watch is still heard at some distance from the ear. In several of Schwartze's cases even the large tuning-fork C was heard indistinctly or very faintly when placed on the vertex.

Our knowledge of the pathological anatomy of syphilitic catarrhal inflammation is very imperfect, as it must be of all diseases which are not fatal.

Moos,[38] Toynbee, Schwartze, Roosa[39] and Kirchner[40] present some pathological findings but none of these seem to the writer to be at all characteristic of syphilis except that in Kirchner's case there was observed a definite endarteritis which involved the arteries of the affected mucosa and this seemed to produce some

*Wilde applies the term myringitis to the disease now generally called acute catarrhal inflammation of the middle ear.

bone changes. I have no doubt that equal care in cases coming to microscopical study will develop spirochetes sufficiently clearly to make a definite assertion that the process is syphilitic beyond doubt.

Woakes[21] claims to have seen through the drum membrane a gummatous exudation in the tympanic cavity.

From what has been said with regard to the symptoms, it must be evident that there is none by which we can positively distinguish chronic catarrhal inflammation of the middle ear, due to syphilis, from that arising from other causes. The supervention of symptoms indicative of disease of some part of the acoustic nerve (impairment or loss of bone conduction, etc.) in the earlier stages of the disease, occurs unquestionably much more frequently in the syphilitic cases than in others, but is by no means a positive sign of the specific character of the disease. Such symptoms, when present, especially in young and middle-aged persons, should, however, arouse our suspicion as to the presence of syphilis, and lead us to make a very careful search for other symptoms of this disease. Only when such are found, or a clear history of constitutional syphilis can be obtained, are we justified in making the diagnosis of syphilitic ear disease.

The prognosis of the syphilitic chronic middle-ear catarrh is, on the whole, even less favorable than that of the idiopathic form. Nearly every writer has met with some cases in which, under judicious local applications and a thorough course of antisyphilitic remedies, the hearing was improved and even restored. But such cases are, after all, according to the writer's experience, rarely encountered—outside of the books. To arrest the progress of the disease is about the most we can hope for.

In the treatment of this disease it will be found necessary, in addition to the usual remedial measures for the ordinary chronic catarrhal inflammation, to resort to constitutional remedies. In all cases in which no doubt exists as to the diagnosis, the patient should be brought rapidly under the influence of mercury by inunctions or injections under the skin, and this should be kept up for a considerable period. Iodide of potassium may be given at the same time. The muriate of pilocarpine, in doses of gr. $\frac{1}{6}$ to gr. $\frac{1}{4}$ administered hypodermically, once daily for several weeks, has been of some service in the hands of Politzer, Lucae, and others, in cases complicated with disease of the inner ear.

*Purulent Inflammation.*—Among the writers on otology much diversity of opinion has always existed as to the occurrence of a syphilitic purulent inflammation of the middle ear. Thus, Frank[42] and Lincke[43] describe an otitis interna the result of lues. In this form, they say, the inflammation and ulceration extend from the throat and nose to the ear, are accompanied by great pain, and often terminate in suppuration of the middle ear, destruction of the tympanal membrane, and caries of the temporal bone. Wilde (*op. cit.*, p. 252), on the other hand, says that under certain circumstances such a disease may, no doubt, occur, although he himself has never seen a case and has not met with a well-authenticated instance of it recorded. Kramer[44] doubts that syphilis can cause a specific disease of the ear, and adds that he has never in his own practice, or in that of others, observed such cases, and Erhard[45] is of the same opinion. Virchow[46] mentions, as the result of syphilis, primary purulent inflammation of the tympanic cavity; stricture of the Eustachian tube resulting from cicatricial closure of its pharyngeal mouth; and caries of the temporal bone. In the treatises on diseases of the ear of more recent date, but little can be found relating to this disease. Politzer (*op. cit.*, p. 330) devotes less than a page to it, and Gruber (*op. cit.*) merely mentions syphilis as one of the causes of otitis media purulenta. Pritchard,[47] in speaking of the affections of the middle ear caused by syphilis, says that they are of comparatively rare occurrence, and that in some cases suppurative catarrh is set up with perforation, etc. Pomeroy (*op. cit.*, p. 239) thinks that syphilis may interrupt the progress of the disease toward recovery, and Schwartze (*op. cit.*, p. 176) only says, with regard to this disease, that under the influence of constitutional syphilis the suppuration may become chronic. Troeltsch, Roosa, Burnett, and others make no mention of it whatever. It may also be stated here that the number of cases of this disease reported in the medical journals within the last twenty years is exceedingly small.

Of our present knowledge of this form of otitis media purulenta it cannot be said that it is much more definite than it was in Lincke's time. Schwartze has seen cases in which syphilitic disease of the fauces was absent, but most other writers, including the present, have found such an affection existing in nearly every case. The disease of the nasopharyngeal cavity may be any one of the various manifestations of constitutional syphilis met with in this locality, or may be a primary chancre due to the accidental inoculation of this part during catheterization of the Eustachian tube. Fortunately such accidents have but very rarely occurred.

With regard to the symptomatology and course of the purulent otitis media, most authors are agreed that they do not differ essentially from the non-syphilitic form. Buck,[15] while not disputing this statement with any great degree of positiveness, owing to the scantiness of the material which has come under his observation, cannot help feeling that, with increased experience and a closer study of this particular class of cases, we shall in time learn to recognize in these parts textural lesions as distinctly characteristic of syphilis as are most of its external manifestations. In one of the cases reported by him (Case XII.), a second perforation developed in the drum membrane more than two months after the first, through a melting process similar to that observed so frequently in the velum palati, and he regards this occurrence as totally different from anything that he has ever observed in any case of non-syphilitic inflammation of the middle ear. Probably a similar melting away of a limited area of the drum membrane took place in another of his cases (Case XI.). In neither of these cases was there any evidence of pressure from within. In the first-mentioned case caries and facial paralysis were subsequently developed, while there was no evidence of interference with the free escape of the pus formed, and this Buck regards as certainly not in harmony with the ordinary course of non-syphilitic otitis media purulenta acuta. Politzer and others frequently noticed a high degree of deafness in these cases, caused by the frequent simultaneous occurrence of syphilitic disease of the labyrinth. Of the occasional occurrence of condylomata and ulcers in the external canal, in connection with this disease, mention was made in the first part of this article. In the cases observed by Kipp the symptoms were precisely those of the non-syphilitic form, and the course and termination of the disease differed in nowise from the other. Ulceration of the mucous membrane, with caries and necrosis of the walls of the tympanic cavity, the mastoid process, and the petrous portion, and facial paralysis, may, according to Politzer, occur under unfavorable circumstances or inappropriate treatment, and end fatally through some intracranial affection. Caries has been observed in this form probably no more frequently than in the non-syphilitic forms.

Fatal hemorrhage from erosion of the internal carotid artery, caused by caries of the canal of the vessel, has been observed in syphilitic, as well as non-syphilitic, subjects. Thus we find in the nineteen cases of fatal hemorrhage collected by Hessler,[48] two in which syphilis was present. One of these cases (reported in full by Tüngle[70]) occurred in a patient suffering from

tertiary syphilis. Two years after he had come under observation he had a sudden profuse hemorrhage from the left deaf ear, and four months later, after repeated hemorrhages, he died. An autopsy revealed a complete destruction of the interior of the petrous portion of the left temporal bone. The membrana tympani and ossicles were wanting. Of the other case (described by Pilz in his dissertation, "De Arteriæ Carotidis utriusque Ligatura," Berlin, 1865) it is only known that, after severe pain in the region of the right ear, without objective symptoms, a sudden and copious hemorrhage occurred from this ear: subsequently the blood was mixed with pus. The patient had syphilis, and a fistula on the posterior wall of the pharynx from which pus escaped. After repeated hemorrhages Billroth first ligated the right and then the left carotid. The patient died under symptoms of anemia. The autopsy showed extensive caries of the lower wall of the carotid canal, exposing the vessel. The eroded spot in the artery measured 8 mm. in length and 6 mm. in breadth.

Metastatic iridochoroiditis of the eye on the same side as the purulent middle-ear disease, developed in a syphilitic subject, observed by Kipp.[49] In this case the ear disease was arrested and the hearing restored under general treatment alone.

As regards the *diagnosis*, the writer must confess that he knows of no aural symptoms by which the syphilitic form of this disease can be distinguished from the ordinary form. Woakes[41] thinks that the caries due to syphilitic purulent inflammation of the middle ear frequently has this distinguishing feature: the caries is symmetrical, that is, there is a corresponding lesion in both ears. In this disease, as in the diseases previously described, the presence of other symptoms of syphilis can alone decide the diagnosis.

Of the *pathological anatomy* of syphilitic suppuration of the middle ear we know but little. Quite recently Moos and Steinbrügge[50] have had the opportunity to examine both temporal bones of a case of tertiary syphilis. Moos first saw the patient fourteen years before his death. At that time the faucial orifices of the Eustachian tubes were closed by numerous thick, radiating, fibrous bands, so that the ventilation of the drum cavity must have been almost impossible; notwithstanding, there was no demonstrable deviation in the plane of the drum membrane, in the position of the handle of the hammer, or in the cone of light. Strange to say, the patient never complained of subjective noises nor of dizziness. Bone conduction was always sufficiently preserved to detect the loud tick of a watch and the tuning-fork; the capacity for hearing speech was, however, so much reduced that ordinary conversation was not heard beyond one meter. The patient remained under Moos' treatment for about two years, and then passed from under his observation till a week before his death. At this time he was examined by Steinbrügge, who found that he was now able to hear spoken words only in close proximity to the ears; a watch of twelve meters normal hearing distance was heard merely on a contact in the right ear, and not at all in the left. Tuning-fork $A^1$ applied to the forehead was not perceived, applied to the teeth it was heard in the left ear. The otoscopic examination of the right ear revealed a cicatrix in the inferior posterior quadrant of the membrane; the external canal of the left ear contained pus, and there was a round, medium-sized perforation directly under the handle of the malleus. Post mortem, the following conditions were found: Syphilitic caries of the skull and hard palate; chronic pneumonia; amyloid degeneration of the spleen, kidneys, and liver.

Then there follows a very complete and exhaustive report in detail which, as far as the writer can observe, although describing numerous diseased areas failed to develop anything very obviously different from the changes found in temporal bones when extensively diseased from other causes than syphilis. This is equally true of the case reported in detail by Betz[51] where the lesions were much less numerous and obvious. This statement is based upon a very careful study made by the writer of two cases of extensive disease of the temporal bone, some of the details of one of which are referred to in the article in this volume under the heading of Tuberculosis of the Ear. We could but wish that some of the material so patiently worked over by Steinbrügge could have also been examined for the *Spirochæta pallida*, for the inference would be that at least those diseased areas where they found the spirochetes should be designated as due to the action of the syphilitic infection.

The *prognosis* is favorable only in the beginning of the ear disease, in the milder cases, and in persons of strong constitution; but when this disease occurs in cachectic individuals, or is complicated with polypi and caries, or the hearing is totally destroyed, the prognosis is very bad. Yet recovery has been observed under judicious general treatment in cases which seemed hopeless.

*Neuralgia of the middle ear*, due to constitutional syphilis, is an extremely rare disease. Usually syphilitic disease of the faucial orifice of the Eustachian tube or of some part of the pharynx or larynx is present at the same time, and is probably the starting-point of the pain in the ear. The entire absence of objective symptoms of disease of the tympanic cavity, and the paroxysmal character of the pain, will establish the diagnosis. Moos, as we have seen, thinks that the hemorrhage in the neurilemma of the plexus tympanicus, as well as the proliferation of the periosteum which he found in one of the cases examined by him, explains to us the genesis of many cases of so-called pure "nervous otalgia," occurring without objective signs of the ear disease in the course of constitutional syphilis. Kirchner[40] also believes that the otalgia is due to a periostitis and disease of the vessels of the tympanic cavity.

The treatment of all of the foregoing affections must be directed against the constitutional disease. In the case of the middle ear affections the local treatment differs in no wise from that which should be given in non-syphilitic cases. In the neuralgic cases the local treatment would be applied to the areas in the throat which are usually causative of the pain. Schwartze has found of especial use gargles of a solution of the bromide of potassium in such cases.

The Eustachian Tube.—Instances of primary syphilitic sores at or near to the pharyngeal orifice of the Eustachian tube have been observed, according to Politzer, by Ricord, Lancereaux, Blanchet, Fournier, Bouquay, Laboulbène, Baratoux and others. J. Solis Cohen ("Diseases of the Throat," p. 113) says that he has seen a fearful case of ravage from a chancre (locality not specified), communicated by the incautious use of the Eustachian catheter. The present writer saw one of the posterior wall of the nasopharynx in a nurse in a foundling institution apparently contracted from blowing out the nipple of the nursing bottle of a syphilitic baby. Whether in the subsequent contraction due to scar formation, the tube of the right side became contracted and thus middle-ear disease started, the writer did not have a chance to observe. In the early stage no ear trouble was noted. Chancres of the nasopharyngeal cavity are, however, according to all writers, of extremely rare occurrence. The contagion is probably always conveyed through the Eustachian catheter. The sores present no characteristic features. The floor of the chancre is usually indurated and the lymphatic glands at the angle of the lower jaw are commonly much enlarged. The sore, as a rule, causes but little pain. Primary chancre of the pharynx, like erratic chancres occurring in other parts, is usually single.

Constitutional syphilis rarely causes isolated affections of the Eustachian tube. As a rule, the adjacent

mucous membrane is the seat of the same morbid process. The earlier manifestations of syphilis met with in this locality are erythema, mucous patches, and superficial ulceration, and the amount and character of trouble produced varies greatly. In brief it may be said that the character of the process is exactly the same as in any other portion of the pharyngeal cavity, and the same general rules of diagnosis and treatment would apply.

Zauf[52] thinks that the plica salpingopharyngea is most frequently the seat of gummata. Whether this be true or not, it seems to the writer to be of prime importance to make an early diagnosis of any ulcerative lesion in this region, hoping thereby to lessen by an early cure the amount of destruction of tissue and the consequent disturbance of the patency and function of the tube. To this end he would, in cases of doubt, commend using the Wassermann test, and in cases of failure to obtain positive reaction, to try salvarsan injections with the double hope that not only is it possible to make a positive diagnosis thereby when the Wassermann fails, but the quickest means to start the healing process has also been used.

Concerning the untoward effects which have been observed upon the inner ear when salvarsan has been used and which might argue against its employment in those cases of tubal disease, where the aural structures are involved, much has been written in recent literature, and this will be taken up later thoroughly in this article.

*Hyperostosis and exostosis* of the osseous part of the Eustachian tube are, according to Gruber,[53] sometimes caused by syphilis. This is, however, denied by other writers.

Mastoid Process.—*Osteosclerosis* and *hyperostosis* of the mastoid process are, according to Schwartze, sometimes caused by syphilis. We know of no signs by which a differential diagnosis can be made between the idiopathic and syphilitic forms of these diseases. A course of antisyphilitic treatment will, however, soon decide which form we have to deal with. Gummata of the mastoid cells are extremely rare. Superficial and extensive caries of the outer cortex of the mastoid process, without disease of the middle ear, occurs, according to Schwartze, only as the result of syphilitic or tuberculous periostitis. The syphiloma or gumma may develop under the picture of a periostitis of the mastoid process. It may break down in parts and simulate the feeling of fluctuation. Its development may be very rapid, and it may disappear as quickly under antisyphilitic treatment.[54]

The Inner Ear.—Of the affections of the organ of hearing caused by syphilis, diseases of the inner ear are probably least frequently met with. These diseases usually make their appearance toward the latter part of the secondary stage, or at a still later period. According to Politzer, they are sometimes developed simultaneously with secondary skin or throat affections, and in one case observed by him, a disease of the inner ear appeared as early as the seventh day after the primary infection. The same author has also recorded a case in which labyrinthine disease was developed simultaneously with a gumma of the skull, twenty-one years after infection; and Kipp has notes of a case in which sudden and absolute deafness of one ear, in connection with nasocranial osteitis, occurred twenty-six years after the primary disease, and after an interval of more than twenty-five years of complete freedom from symptoms of constitutional syphilis. Hutchinson ("Syphilis," p. 32), on the other hand, has no knowledge of any form of deafness due to syphilis which occurs in the tertiary stage of the acquired form.

The present writer thinks, with Frey[66] and Glogau[67], that we greatly underestimate the number of cases where acquired syphilis affects the inner ear. Very much more is now known concerning the anatomy and clinical physiology of the acoustic and static inner ear, and with the added impulse given by the desire to explain why so many cases of internal ear deafness, temporary and permanent, have appeared since the use of salvarsan, more study will be given to this matter. If systematic examination of all syphilitics concerning the hearing function is regularly taken up, very many more cases will be found to exist than has hitherto been thought possible. Very many of these will be found to have started in the early stages of the disease, and being overlooked, would naturally only come into evidence if given salvarsan at a later time.

Frey succeeded in collecting sixty cases of well-authenticated affection of either the vestibular or cochlear branch of the auditory nerve, or both, in the early stages of secondary syphilis.

Glogau quoting Gradenigo, Brueckner, and Gerber states that seven per cent. of all cases of internal otitis are syphilitic—not too strong a statement.

The diseases of the labyrinth may be developed alone or in association with tympanic diseases. Frequently they supervene on preëxisting catarrhal or purulent inflammation of the middle ear.

The *symptoms* of syphilitic disease of the labyrinth do not differ essentially from those of the affection of this part due to other causes. In this form, as in diseases of the labyrinth in general, a marked diminution or total loss of the hearing power in one or both ears occurs, usually more or less suddenly. Subjective noises, of a variable nature, often of great intensity, sometimes precede the onset of the deafness, but more commonly are developed at the same time. They are rarely entirely absent. Vertigo and unsteadiness of gait sometimes usher in the attack, but more frequently these symptoms follow the deafness. Nausea, vomiting, headache, and weakness in the limbs are also early symptoms in many cases. Pain in the ear very rarely accompanies the attack. Inspection of the drum membrane will in many cases give a negative result, while in others it will reveal the changes usually found in connection with chronic catarrhal disease of the middle ear. Evidences of acute inflammation of the tympanic cavity are usually wanting. The air douche through the catheter commonly shows a pervious Eustachian tube, and the sounds heard on auscultation are generally broad and dry.

A closer examination of the hearing power in these cases shows that besides the impairment of hearing for the voice, the perception of sounds through the bones of the skull is either greatly diminished or entirely wanting. In cases in which both ears are deaf, vibrating tuning-forks placed on the vertex or between the teeth are usually not heard at all, and in cases in which only one ear is diseased, the tuning-forks are heard most distinctly in the healthy ear and never only in the affected ear. Placed on the mastoid process of the affected side, the tuning-fork (the writer usually employs for this purpose a small $C^2$ fork of 212 vibrations a second), if heard at all, is heard from this part less long than normally in persons of the same age. In cases of great impairment of hearing for the voice the employment of Rinné's test nearly always shows the predominance of aërial over bone conduction; while in total deafness for the voice small tuning-forks are not perceived at all, but very large ones, when struck with much force, are heard when placed on the mastoid process. The examination with the piano or tuning-forks of different pitch, not infrequently shows that the perception of certain tones of the scale, usually the highest, is diminished or destroyed, or that whole groups of tones are not perceived. In a case observed by Knapp,[55] tuning-forks of high and low pitch were not heard while those of medium pitch were perceived; neither the highest four ($e''''$–$a''''$) nor the lowest four tones ($A^2$–$D^1$) were heard; the octave next to the highest was heard, and that above the lowest tones only feebly. The power of appreciating low tones is the last to suffer and the first to recover in most cases, so

that these will be heard when the high ones are not heard at all, or false, or doubled.[39] In a case reported by Blake and Walton,[56] a tuning-fork (562 v. s.) was heard in the left ear one-fifth higher than in the right; and sixteen days later, tuning-forks (560 v. s. and 1,200 v. s. ) which were heard through the air, and the tone reproduced by the patient's singing, normally in the right ear, were heard and reproduced below their pitch in the left ear; otherwise the hearing was equally good in both ears.

The course of this disease is not always the same in all cases. While the clinical picture usually presented is that of a very rapid decline of the hearing power, till complete deafness is reached, the progress in the impairment is in some cases comparatively slow. In cases observed by Politzer, nearly total deafness was present three days after the onset of the disease. Concussion of the head, sometimes in slight degree, will occasionally cause a rapid increase in the deafness in these cases (Politzer, Troeltsch, Urbantschitsch, Gruber). Fluctuation in the deafness is less often observed in this disease than in affections of the middle ears. The vertigo, unsteadiness of gait, and headache generally continue for a few weeks or months, and then gradually disappear. The hardness of hearing unfortunately often remains, and in the few cases which end in recovery the improvement takes place very slowly.

Syphilitic disease of the labyrinth cannot be distinguished from disease of this part due to other causes, either by the aural symptoms or by the hearing tests employed. The sudden onset of the disease and the rapid progress of the deafness for the voice, together with the absence of bone conduction, are regarded by many authors as peculiar to the syphilitic form of this disease. The present writer has, however, seen quite a number of cases presenting such a history in which syphilis was entirely out of the question, and therefore cannot regard the above-mentioned symptoms as characteristic of syphilis of the inner ear. If, however, the train of symptoms described occurs in connection with undoubted evidence—in the skin, the eye, or other parts of the body—of constitutional syphilis, or in an individual with a clear history of syphilis, we may assume with much confidence that the labyrinth disease is due to the invasion of syphilis. In the absence of history, or of other symptom of syphilis, our suspicion as to its presence should be aroused, nevertheless; and we should make a searching examination for its presence in all cases of sudden loss of hearing, unaccompanied by pain, occurring in vigorous young or middle-aged persons whose nervous system was in a healthy condition previous to the attack, and in whom traumatism or other plausible causes of the deafness can be excluded (Schwartze). In several of such cases in which syphilis was absolutely denied, Politzer was enabled by a rigorous search to prove conclusively that constitutional syphilis was the basis of the ear disease. In this connection it should also not be forgotten that an outbreak of tertiary symptoms may occur after a long period of apparently good health.

The differential diagnosis between this disease and affections of the middle ear involves no great difficulty in recent cases. The absence of objective symptoms of middle-ear disease, and the results of tests with tuning-forks and the piano will decide the diagnosis. The case is, however, entirely different if well-marked signs of middle-ear disease are present, and more particularly if both ears are diseased and the loss of hearing has developed gradually. Under these circumstances the results of even the most patient examination with tuning-forks and the piano will often leave it undecided whether one or the other or both parts are diseased. The supervention of syphilitic disease of the labyrinth upon middle-ear disease may be inferred from the history of the case, the suddenness of the increase in the hardness of hearing, and the result of the hearing tests previously mentioned.

So far as is known to the present writer, Roosa (*op. cit.*, p. 610) is the only author who thinks that we are justified in going a little farther in our classification than merely to state that this is a disease of the labyrinth. We may perhaps, he says, diagnosticate disease of the cochlea, or at least say that the affection of the cochlea is predominant in certain cases (great impairment of hearing, inability to hear certain tones, and the production of false ones), just as we may speak of disease of the semicircular canals, when vertigo and staggering gait are the predominant symptoms. To such cases he applies the name of syphilitic cochleitis.

With regard to the pathological anatomy of syphilitic disease of the labyrinth, it must be admitted that our knowledge is still in a very unsatisfactory state. Indeed Schwartze, than whom no one is better qualified to express an opinion on this subject, does not hesitate to say that we have no anatomical knowledge whatever of this disease, and that the pathological changes in the labyrinth found by Toynbee, Gruber, Moos, Politzer, and others, of which a brief account will be given farther on, cannot be regarded as specific, since the same alterations occur in non-syphilitic cases. The condition of the organ of hearing found post mortem in individuals in whom syphilis and ear disease were known to have existed, was as follows: In a case of secondary syphilis, with catarrh of the middle ear, described by Voltolini,[57] there were found hyperemia of the vestibule, of the commencement of the cochlea, and of the horizontal semicircular canal, and hyperostosis confined to the parts surrounding the fenestra ovalis. Gruber[58] found in a syphilitic subject who had become suddenly totally deaf, and who died from typhus fever, considerable hyperemia of the lining membrane of the tympanic cavity and of the membranous labyrinth, which appeared much thickened. The fluid of the labyrinth was abundant in quantity and bloody in color. It is not stated that a microscopic examination was made. Whether the changes found in this case were the result of syphilis or of the typhus must remain undecided.

Moos[38] made an examination of the right petrous bone of a woman, forty-nine years of age, who had been very deaf on this side and blind in her right eye since her seventeenth year. After going into details regarding his findings in this case he says, "The above-described anatomical lesions of the organ of hearing furnish a sufficient explanation of the total deafness during life. Leaving out of account the myringitis which supervened toward the end of life, the deafness was due to the ankylosis of the ossicles and the chronic inflammation of the labyrinth. Very probably this condition resulted from secondary syphilis, although the microscopic data would not of themselves point to it as a specific cause. As far as I know, we have not as yet reliable anatomical signs of syphilitic inflammation of the labyrinth. We know too little of the pathological anatomy of the labyrinth to be able to decide this question."

In another case of constitutional syphilis examined by Moos,[59] in which violent subjective noises, vertigo, and pain in the bones of the skull were followed later by a remarkably rapid destruction of the hearing power, he found many changes such as may be best described as a general infiltration and hyperplasia of the essential structures in the labyrinth but equally open to the criticism made of his previous case given above. He is to be praised for his efforts to make the subject clearer by such splendid studies.

According to Politzer,[60] recent investigations leave no doubt that, in cases of long duration, a chronic inflammation of the lining membrane of the labyrinth may result in a periosteal bone proliferation in the cavity of the labyrinth. The following case occurred in his own practice: The patient was a man, fifty years of age, who had been totally deaf for ten years in consequence of syphilis. In the right drum membrane two broad, ribbon-shaped stripes extended

downward at an acute angle from the end of the handle of the hammer. Bone conduction was destroyed. Death was caused by phthisis pulmonalis. Autopsy: The ribbon-shaped stripes on the drum membrane proved to be ridges of horny, thickened epidermis. The lining membrane of the tympanic cavity and the ossicles were normal on both sides. In decalcified sections of the cochlea, pathological alterations were mainly found in the ganglion cells in Rosenthal's canal. Within these cells were seen small, round, granular cells without a distinct nucleus, and also oval and annular bodies, in only a few of which a nucleus could be recognized. (Atrophy and degeneration of the ganglionic cells in the ganglion spirale.) The modiolus showed in spots a reticular structure. In the spiral membrane, in the vestibule, and in the semicircular canals no changes were visible which could be interpreted as pathological.

Pathological alterations in the blood-vessels of the inner ear, similar to those described by Heubner as occurring in syphilis of the brain, have thus far been observed only in a case examined by Baratoux.

The *prognosis* must be guarded as regards the recovery of hearing. In acute cases of recent date recovery has occasionally followed the energetic employment of mercury and iodide of potassium; but in cases of gradual loss of hearing or in those of long standing, the prognosis is decidedly unfavorable. Politzer is of the opinion that the degree of deafness is not always decisive for the recovery of normal hearing, since recovery from total deafness has been observed; while, on the other hand, in milder cases, active antisyphilitic treatment not only fails to produce an improvement, but is, moreover, sometimes followed by an increase in the deafness—a statement which cannot be brought into too bold relief when considering the use and effects of salvarsan. This author has also seen patients in whom the deafness came on while they were under the influence of mercury.

*Treatment.*—If the ear disease occurs during the earlier stages of constitutional syphilis, mercury should be used freely, preferably by inunctions, till the system is brought under its influence; after that the remedy must be continued in smaller doses for a long period. Mercurial baths, subcutaneous injections of corrosive sublimate, and the internal administration of calomel, blue pill, and other preparations of mercury, may be substituted for the inunctions when they are objected to. The iodide of potassium, alone or in combination with mercury, is especially useful in cases occurring during the intermediate or tertiary stage. Roosa has obtained very encouraging results from this remedy in very large doses (gr. cxx. to gr. ccclxix. daily), in cases in which smaller doses failed to produce any effect. He used, however, inunctions of the oleate of mercury at the same time. To avoid disturbance of digestion it will be found best to dilute the iodide largely with water, and to administer it in divided portions during meals. Tonics and a generous diet should be given with both the mercury and the iodide to patients in feeble health.

Owing to the fact that many reports have been made where the use of salvarsan has been followed by both temporary and permanent bad effects upon the internal ear, one should surely hesitate to select it as a remedy for this organ itself, when diseased, and yet the writer is wholly convinced that when our knowledge has progressed only a little further we shall be able to select certain cases where it is not only justifiable to recommend its use, but that the results will be as excellent and permanent as they have been in other fields of its usefulness. This last statement is based upon facts now abundantly proved.

1. There are certain cases such as those reported by Theimer[68] and I here quote his opinion where there follows very soon after the injection of salvarsan a marked affection of the vestibular part of the internal ear, which disappears almost as rapidly as it appears, and is perfectly analogous to the "Jarisch-Herxheimer reaction" in the exanthematous stage of syphilis. This is the most fleeting of the effects of salvarsan on the internal ear.

2. There are cases where one or both sections of the internal ear are early affected and the result disappears only after repeated use of either the salvarsan or mercury, or both.

3. There are cases where the effect produced happens long after the injection, weeks or months. Here, too, the lesion may disappear after longer or shorter endeavor.

4. There are cases where the internal ear becomes permanently injured.

Any of these four results may apparently happen to patients where disease has been known to exist, where it is unsuspected, or where the ears have been apparently proved to be normal. As this last is possible, and as such injury to the internal ear is quite as, if not more, likely to remain permanent than where known disease exists, no method is now known for separating those susceptible from those not.

Furthermore, many of the cases recently reported are now given repeated injections, and the trouble disappears, while in the earlier ones, when the remedy was a new one, owing to the fright which the appearance of the trouble caused, treatment was frequently stopped and the salvarsan unjustly given, in many cases, the blame for the permanent injury.

With this all in mind, the writer, while holding no brief for what others should do, feels his duty by his patients as follows: In cases of internal ear trouble associated with syphilis which have been existing but a short time, and where there are other evidences of the constitutional trouble in the middle ear or neighboring upper air passages, and where these either do not yield immediately to mercurial or other treatment, or where the internal ear symptoms are threatening, he would use salvarsan, and repeat if necessary. In cases where the internal ear trouble seems to be the only one present in the ear or neighboring parts, and is of recent origin, and there are other signs of an uncured or unyielding syphilis present, give salvarsan. When the disease of the internal ear is far advanced or has existed a long time, or both, and is not of middle-ear origin, he would refrain from the use of salvarsan. If in a case where salvarsan was used in which the ears were proved or supposed to be normal, internal-ear affection should be precipitated, the use of salvarsan need not be interrupted because of the internal ear affection, for too many have been improved by repeated injections and mercury or the iodides. The effect on other lesions should be the indication to repeat or stop the treatments. And finally, in all, the invariable rule should hold, here as well as elsewhere, that salvarsan should always be used only enough to start and keep up a progressive recovery, but that mercury or iodides, or both, should be the main reliance for a permanent cure. Subcutaneous injections of the muriate of pilocarpine, in gradually increasing doses (gtt. iv. to xij. of a two-percent. solution), have also proved useful in this disease in Politzer's hands. He is of the opinion that it should be tried for from eight to fourteen days in all recent cases, and that mercury and iodide of potassium should be given only if at the end of the above-stated period no improvement is manifest. Lucae, Moos, Barr, Bacon, and others also speak highly of the effect of pilocarpine in these cases, and think it worthy of further trials. Lucae has also seen temporary improvement of hearing follow the application of the artificial leech.

In order to protect the diseased ears as much as possible against the injurious effect of noises, while undergoing treatment, Kipp thinks the patient should be kept in a perfectly quiet room, away from the streets, and it may even be advisable to cover the ears and the side of the head with cotton batting. If

disease of the middle ear is present, this must be treated in the manner already described. Care should, however, be exercised, that the force employed during inflation be not greater than is absolutely necessary.

Acoustic Nerve.—Of the syphilitic diseases of the auditory nerve, beyond the labyrinth, little or nothing is known. An intracranial disease involving some part of this nerve may be assumed, however, if in addition to the symptoms enumerated under the head of diseases of the labyrinth, positive symptoms of intracranial disease are present in a syphilitic individual. Foci of softening in the brain, gummata, circumscribed basilar meningitis or pachymeningitis, chronic periostitis ossificans of the petrous bone, with hyperostotic narrowing of the porus acusticus and paralysis of the trunks of the nerves from compression, are mentioned by Schwartze as the morbid conditions probably present in such cases. Of the morbid changes in the trunk of the auditory nerve and in its nuclei, due to syphilis, we have no knowledge.

Inherited Syphilis.—Affections of the ear due to inherited syphilis are met with at two periods of life, during the first year and between the fifth and twenty-fifth years of age.

In Infants.—In infants suffering from syphilitic disease of the nose and pharynx, affections of the middle ear are of common occurrence. Both the catarrhal and the purulent inflammations of this part, occurring under these circumstances, present no features by which they can be distinguished from the non-syphilitic form of inflammation. Caries and necrosis of the ossicles and the walls of the tympanic cavity may perhaps be developed more frequently, or more speedily, in the syphilitic than in the ordinary form, but no statistics are available by which this is proved. As in many of these cases the general health is seriously impaired by the constitutional disease, often but little attention is given to the ear affection by the parents or the medical attendant of the infant, and treatment is delayed until great destruction has already taken place. In a case of purulent inflammation of both middle ears, of two months' standing, reported by Kipp, paralysis of the right facial nerve existed when the patient was first seen, and paralysis of the left facial and exfoliation of the hammer and anvil of both ears occurred a few days later. The child was greatly emaciated, and although mercury was given at once and the usual local treatment pursued, the child died two weeks later, apparently from marasmus. The prognosis is probably less favorable in syphilitic cases than in otherwise healthy children, but under proper general and local treatment, begun shortly after the appearance of the disease, many cases make a good recovery. Concerning the pathological anatomy of diseases of the ear in syphilitic infants, we know but little. Baratoux[4] who made autopsies of forty-three still-born or new-born infants with hereditary syphilis, found lesions of the middle ear twenty-three times, lesions of the labyrinth four times, and lesions of both parts twelve times. When the internal ear was affected simultaneously with the middle ear, without pus being formed in the labyrinth, the walls of the ampullæ and cochlea were reddened; the axis of the cochlea was injected and infiltrated with round cells, and the parts were bathed in a serosanguinolent fluid which had taken the place of the lymph. When the internal ear alone was affected, the blood-vessels were found dilated, the walls were thickened, and in some instances hemorrhagic spots were found.

The local treatment of these diseases does not require any other measures than those usually employed in the non-syphilitic form. Local treatment will, however, accomplish but little so long as the constitutional disease is active. For this mercury must be given; gr. x. of the mercurial ointment rubbed into the palms and soles twice daily, as recommended by Hutchinson, will usually make the symptoms disappear very rapidly. Iodide of potassium is rarely beneficial in these cases.

In Childhood and Adolescence.—*The Drum Membrane.*—Special affections of the external canal and drum membrane are doubtless of very rare occurrence in connection with syphilis hereditaria tarda. The only case of such a disease on record, so far as the writer knows, has been described by Pomeroy[61] under the heading Papulo-tubercular Affection of the Drum Membrane in a Subject of Hereditary Syphilis. In this case, that of a boy, eighteen years of age, with parenchymatous keratitis and considerable impairment of hearing, both drum membranes, just behind and below the malleus handle, were the seat of a nodular, grayish mass of triangular form. Large blood-vessels traversed the region of the tumors. Efforts to remove the masses by wiping with cotton-wool were unsuccessful. After a few days the color of the tumors changed from gray to a dull red, and after the tumors had disappeared vessels of large size remained. Under constitutional treatment and inflation of the tympanic cavity the drum membrane regained its normal appearance in about six months. Pomeroy infers that the tumors were in the dermal layer of the drum membranes, as the malleus handles and short processes were distinctly behind the tumor. The drum membranes were not perforated. It is not denied that there was more extensive disease than this, there evidently being an inflammation of the drum cavity with exudation into the tympanal lining, including that covering the round and oval windows. The tuning-fork tests pointed to a suspicion of labyrinthine disease, but actual proof of that did not exist.

*Middle and Inner Ear.*—In the offspring of syphilitic parents, and almost exclusively in those of the female sex between five and twenty-five years of age, there occurs occasionally a disease of the ears producing in most cases great impairment of hearing or total deafness in a short space of time. The connection between the ear affection and inherited syphilis was first pointed out by Hutchinson,[62] though von Troeltsch and others had previously mentioned the occurrence of hardness of hearing in the children of syphilitic parents. Wilde's familiarity with the disease under consideration is shown by his remark: "It sometimes coexists with, sometimes alternating with, the ocular disease." "What is termed strumous ophthalmia, and also corneitis, are the forms which the eye affection assumes. Occasionally it is that of iridochoroiditis." Since the appearance of Hutchinson's paper numerous cases of this affection have been put on record by various authors, and the clinical history of the disease is now well known, but our knowledge of its pathology is still very meager. This disease is by no means of as frequent occurrence as the eye affection of inherited syphilis, and is, as has already been observed, found chiefly in the female sex. Kipp met with it (or rather saw it associated with well-marked symptoms of inherited syphilis) but once in a male, while he has notes of over twenty cases occurring in females. Other physicians have had a similar experience. The disease seems to be, from all accounts, of less frequent occurrence in this country and in Germany than in England, where, according to Hinton, five per cent. of the aural patients treated at Guy's Hospital, London, suffered from it.

The subjects of this disease of the ears have, in many cases, manifested symptoms of hereditary syphilis during the first year of their lives, and usually have enjoyed good hearing during early childhood. The ear disease usually begins between the fifth and twenty-fifth years of age, and is commonly preceded by an attack of parenchymatous keratitis or of an inflammation of the uveal tract of one or both eyes.

Not infrequently the ear disease commences while the eyes are still inflamed, and occasionally it precedes the eye disease. Painless swellings of the larger joints, more particularly of the knees, which pass away without much treatment, are often present at the same time, or are developed later on. In most of the cases, the patients or their guardians are unable to assign an immediate cause for the ear trouble; but occasionally, as in one of Gradenigo's cases[63] and in one of Kipp's cases, both of which occurred in young women, the deafness was attributed by the patients to exposure, particularly of the head, to draughts of cold air while the hair was wet. The present writer now has a case in charge where the young woman asserts that a fright caused nervous prostration and the trouble began at that time. The first symptom to attract the attention of the patient, or of those who are with her, to the ear affection is a sudden and marked impairment of hearing. Pain in the ear is almost never complained of. Vertigo, unsteady and staggering gait, subjective noises, and headache accompany the hardness of hearing in most cases. In a number of cases seen by Kipp, vertigo and headache preceded the impairment of hearing; while in others these symptoms developed afterward. Occasionally nausea, vomiting, and headache usher in the attack. The hardness of hearing, which at first perhaps may not be of the same degree in both ears, increases steadily, and often very rapidly, to total deafness. Sometimes total deafness is found to exist as early as the second or third day after the beginning of the attack, but more commonly a period of from six to ten weeks elapses before this stage is reached. Occasionally the progress is still slower, and is then usually characterized by marked variations in the degree of deafness from day to day.

The vertigo and the staggering gait usually continue for months and then gradually pass away. The deafness, after it has once become total, nearly always remains so. In several of the cases seen by Kipp, a perforative purulent inflammation of the middle ear, of one or both sides, develops several years afterward.

In the beginning of the disease the patients can usually hear the tuning-fork (the writer uses tuning-forks which, when struck with moderate force, are heard for from thirty to forty seconds normally when vibrating in the air near the ear) longer and louder through the air than through the mastoid process. The tuning-fork $C^4$ (2,048 vibrations a second) is often not heard at all. In some cases bone conduction for tuning-forks of small size, of high and low pitch, is entirely abolished, while massive forks (for instance Politzer's C fork, described and illustrated in his "Lehrbuch," 2d ed., p. 117) are still heard through the mastoid. In cases of complete deafness of both ears, seen by Kipp, he found that the tuning-forks C (1,285 v. s.), $C^1$ (2,565 v. s.), $C^2$ (5,215 v. s.) were heard both through the air and through the mastoid only when they were struck with great force, and louder and longer through the mastoid than through the air. None of these forks was heard from the vertex or when placed between the teeth, but the large C fork of Politzer (which is two or three times larger than the others mentioned) was heard from vertex and teeth. The tuning-fork $C^4$ was not heard at all. The shrill whistle of a distant factory was heard. Their own voices the patients could scarcely hear. In other cases of total or nearly total deafness of both ears, in which also only the large tuning-fork C was heard, Kipp found sometimes a preponderance of bone conduction over aërial in one ear, while the other ear gave an opposite result. Gradenigo (*op. cit.*), who used tuning-forks of the same size and make as Kipp, obtained similar results from his experiments. The examination of children with tuning-forks is, however, in most cases, very unsatisfactory in its results, as many of them are apathetic and indifferent, and can rarely be induced to produce, by singing, the tone of the fork, and one is, therefore, never certain whether they hear the fork or simply feel its vibrations.

The objective examination of the ear may reveal a perfectly normal condition of the drum membrane, the tympanic cavity, and the Eustachian tube, or evidence of present or past disease of these structures. Acute catarrh of the middle ear will be found present in an inconsiderable number of cases, and changes in the drum membrane, evidently the remains of bygone disease, in many others. Symmetrically placed areas of redness (localized periostitis) on the posterior and upper wall, in close proximity to the drum membrane, in both external canals, were observed in a well-marked case of this disease by Buck. Disease of the nasopharynx is as often present as it is not. Perforating ulcers of the hard and soft palate, caries and necrosis of the nasocranial bones, and ulceration of the larynx will be found in a small percentage of the cases.

The diagnosis of the peculiar ear affection under notice presents no difficulty if, in addition to the aural symptoms previously described, other symptoms of syphilis hereditaria tarda are present or have preceded the ear trouble. In addition to the eye diseases already mentioned, these patients often suffer from chronic inflammation of the knees or other large joints. The knees are often very much enlarged and locomotion may be painful, but there is rarely spontaneous pain. The disease usually passes off in the course of a few weeks, leaving the joints apparently in as good a condition as they were before the attack. Nodes on the long bones are also not infrequently present. With regard to the peculiarities of the teeth, Hutchinson says: "If the upper central incisors are dwarfed, too short, and too narrow, and if they display a central cleft in their free edge, then the diagnosis of syphilis is almost certain. If the cleft is present and the dwarfing absent, or if the peculiar form of dwarfing is present without any conspicuous cleft, the diagnosis may still be made with much confidence." Perforating ulcers of the hard and soft palates, deep ulcers of the pharynx, caries and necrosis of the nasocranial bones, and laryngitis are less often seen than other affections above mentioned. The patients, moreover, often have withered and old-man-like features, a peculiar square form of the forehead, prominent frontal eminences, a sunken nose, and scars about the angles of the mouth.

With regard to this disease Hinton[34] remarks that he knows of no other affection, except fever, which in a person under twenty years of age brings on a deafness so rapid and complete, and Hutchinson says that it may be broadly stated that if a child or young person, without either earache or otorrhea, becomes quickly and completely deaf, the patient is almost certainly syphilitic. Kipp has, however, met with two cases, both in vigorous boys, without the slightest sign of syphilis, in whom nearly total deafness was very rapidly developed while they were in excellent health. No disease of the middle ear could be discovered, and no febrile disturbance preceded or accompanied the onset of the deafness. Examination failed to reveal intracranial disease at the time, and none has developed since. The parents of these boys absolutely denied having had syphilis. Other otologists have doubtless met with similar cases, and have, like the writer, come to the conclusion that hereditary syphilis of the ear cannot be diagnosed from the symptoms presented by the ear affection alone.

From the ordinary catarrhal inflammation of the middle ear (from which syphilitic children are no more exempt than others) the disease here described can be readily distinguished by the clinical history and the results of the local treatment.

In the absence of postmortem examinations of the organs of hearing of typical cases of this disease, the writers on this subject are divided in their opinion as to the seat of the lesion. Hutchinson thinks it tolerably certain that the internal ear or the nervous apparatus

is the seat of affection, but as to the exact site and the nature of the morbid process he is still in doubt, and most English writers are of the same opinion. Politzer and Schwartze do not hesitate to speak of the disease as inherited syphilis of the labyrinth, and Gradenigo calls it a syphilitic otitis interna. The view that both the conducting and the nervous apparatus are liable to be involved in the disease is held by Hinton and others, and Roosa has come to the conclusion that the disease is one chiefly of the peripheral and not of the central part of the organ of hearing. The view expressed by Kipp[64] that disease of the nuclei of the auditory nerves might be the cause of the deafness, he has now abandoned, and a larger experience and further study of the disease leave but little doubt in his mind that the labyrinth is involved in all cases, and that in many, both it and the middle ear are the seat of the morbid process. The apparently normal state of the accessible parts of the middle ear found in acute cases, together with the total deafness for the voice with which the disease ends, must be regarded as strong evidence that the auditory nerve is the part affected, and the absence of other signs of cerebral disturbance makes it positively certain that its terminal apparatuses are chiefly affected. The results of tuning-fork tests cannot be utilized, as we have seen, in the settlement of the question as to the seat of the disease. That in many cases evidences of disease of the middle ear are not wanting is generally admitted, but they are rarely sufficiently marked to account for the profound deafness. The usual treatment for the middle-ear affection of children, moreover, is rarely followed by improvement in the hearing, even in the cases in which, under it, the objective signs of the disease disappear.

The purulent inflammation of the middle ear, with perforation of the drum membrane, which developed in several of Kipp's cases years after the attack which destroyed the hearing, may have been due as well to a gradual increase in the inflammation of the lining membrane of the middle ear as to an extension of a purulent inflammation from the inner ear of the tympanic cavity.

*Treatment* is generally regarded as of no avail in any except very recent cases. Hutchinson thinks it more than justifiable, having regard to the terrible results in prospect, *in early* stages of ear disease of this type from inherited taint to confine the child to bed and induce ptyalism quickly. Knapp has reported a case in which a cure occurred under the use of mercury; but the writer, who adopted Hutchinson's advice in a number of cases, has been unable to arrest the progress of the disease in a single one. The iodide of potassium has been given in such cases by the writer for many years, and sometimes with apparent benefit, which, however, was generally transient. Buck saw marked improvement follow the administration of this remedy in gradually increasing doses (gr. v. to gr. xxxviij. three times a day). If middle-ear disease is present, it should be treated by inflation and other means, and even in cases presenting no marked evidence of a middle-ear affection it is best to give the patient the benefit of the doubt and treat him locally as well. Pritchard advises repeated blistering behind the ear for several months in all cases, and as it can do no harm it may be worth while to try it. Hinton has seen striking improvement follow in a severe case from scruple doses of chloride of ammonium, and has seen good effects produced by the injection of iodine vapor into the tympanum in less marked cases. Favorable hygienic surroundings and a sufficiency of good food are, of course, to be desired in the treatment of all cases of ear disease, but, if the writer may judge from his personal experience, they have little or no influence on the course of this disease.

HENRY L. SWAIN.

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**Ear, Tuberculosis of the.**—The occurrence of a purulent discharge from the ear in the latter days of patients afflicted with phthisis pulmonum was observed by the earliest clinical writers, who attributed it to poison within, seeking its way out. Naturally, nothing very precise was written on the subject until the use of the head mirror, which afforded a more exact way of observing the conditions occurring in various diseases, had been discovered. After this discovery had been made, certain peculiarities of the objective appearances in ear tuberculosis were soon chronicled.

As in most other pioneer otological work, so here also we find evidences of the fact that Politzer contributed his share. In his "Beleuchtungsbilder," published in 1865, he pictures one of the typical appearances of this condition. He was one of the earliest observers to write at all extensively on the subject, and gave one of the first satisfactory descriptions of the microscopic changes taking place in the mucous membrane of the middle ear in this disease. Still later, when tubercle bacilli were discovered, we find him one of the first to work out the presence of these in the discharge and in the ulcerated membranes.

During this interval many other observers worked upon the subject from various standpoints until to-day we find tuberculosis of the middle ear thoroughly well recognized, exhaustively studied, and in general as well understood as tuberculosis of any other organ or portion of the body.

Etiology and Pathology.—Theoretically, there is no reason why a tuberculosis cannot begin primarily in the ear, but, owing to the fact that the middle ear is shut off from the rest of the body, and communicates only indirectly with the lymphatic system—the great disseminator of tuberculosis, and also in view of the fact that the only direct connection which it possesses with the outside world is through a very narrow tube which passes down into the nose, we have a right to assume that it can only rarely serve as the primary source of a general tuberculosis. Cases have been reported in which the discharging ear furnished the first objective symptom, while only later, sometimes after a considerable lapse of time, did the lung and other symptoms manifest themselves. I have myself, however, never seen any cases in which I could satisfy myself that I had before me a genuine instance of primary middle-ear tuberculosis. There is one fact, however, which is indisputable, viz., that in the vast majority of cases the ear tuberculosis manifests itself long after the disease has been more or less active in some other part of the body.

How often aural complications occur in tuberculous subjects, it is not possible to state in exact statistics, all of the latter being more or less modified by the fact that the ear trouble is often so little noticed by the patient (and even less so by his medical attendant) that a great many patients even in our best-managed institutions die without any mention being made on the record of any discharge from the ear. In private practice a still larger number of cases remain undiscovered, or, if mentioned, are soon forgotten as being, in the presence of disease elsewhere in the body, unimportant. For these reasons I am disposed to believe that tuberculosis affects the middle ear much more often than is generally supposed.

It is probable that tuberculosis in the middle ear develops in one of two ways: either the tubercle bacilli effect a lodgment in the relatively healthy but constitutionally vulnerable tissues of the membrana tympani and middle-ear mucous membrane, or else they are favored, in making a successful invasion of the ear, by the fact that these parts are weakened by disease (infection by streptococci, pneumococci, etc.). The mode of approach of the bacilli, which doubtless are in the air-passages a large part of the time, especially where a lung tuberculosis already exists, is clearly by way of the Eustachian tube.

It is interesting to note, in this connection, that oftentimes the most careful and persistent search (microscopical and bacteriological) fails to discover the existence of tubercle bacilli in either the discharge or the affected tissues themselves, and that too in cases which present the strongest possible clinical evidences of the existence of a tuberculous process in the middle ear. This experience has happened to the author in a number of instances.

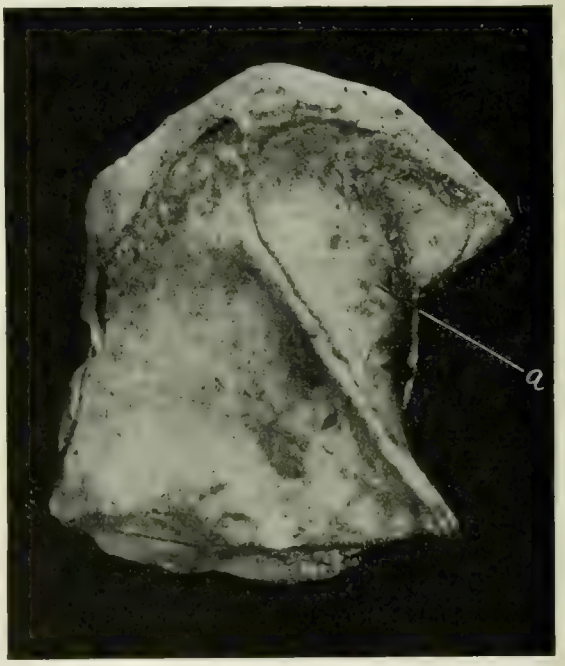


Fig. 1940.—Cast of Petrous Portion of the Temporal Bone, from a case of advanced tuberculosis of this part of the skull. (Original.) *a*, Roof of the tympanum, which is seen to be arched up into the middle fossa of the skull. The overlying brain substance at this point showed a corresponding depression.

It seems natural to inquire next as to the nature of the pathological processes which take place in the ear; how they progress step by step. The inflammation is almost always of the sluggish, asthenic type. Without much disturbance a discharge appears, and then, shortly afterward, a large part of the drum membrane will frequently disappear. Thus, sometimes, in the course of only a few hours, a whole quadrant will as it were melt away, or two independent perforations will form, will persist for a short time, and will then merge into one large defect. After this first loss of

substance has taken place, frequently nothing further transpires beyond the simple conversion of the mucous membrane on the promontory wall of the middle ear into a granulating mass, and from this and the whole cavity of the middle ear there is secreted a thin acrid

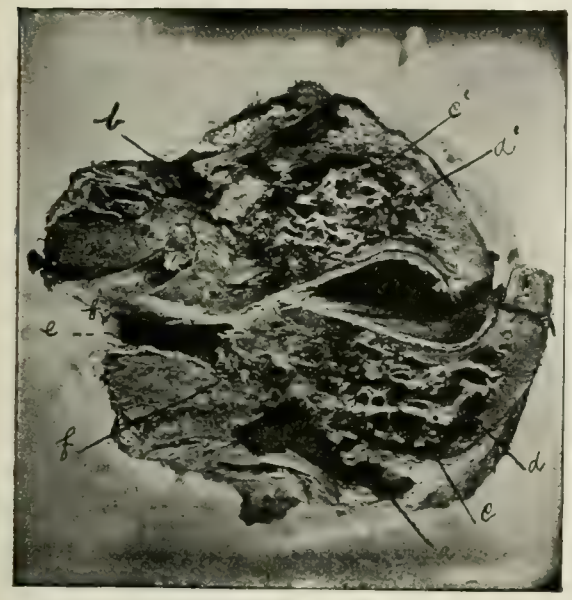


FIG. 1941.—Temporal Bone from the Same Case as that shown in Fig. 1940. The section (made with a saw) passes horizontally through the external auditory canal. Slightly reduced. (Original.) *a*, The floor of the external auditory canal and lower half of the middle ear; *b*, the upper wall of the canal, while the upper half of the middle ear is filled by a caseous mass; *c*, *c'*, section of a sequestrum or of a portion of the bone which is in a condition of osteoporosis (the extent of the same may be readily distinguished); *d*, *d'*, intact outer table of the skull; *e*, locality of the cochlea which had been involved in the necrosis of the neighboring bone structures; *f*, *f'*, caseous mass in the internal auditory canal.

pus which, often in no very large amount, runs on for months and months until the demise of the patient. No very great further destruction of tissue takes place, and the granulating surfaces do not ulcerate, but most obstinately persist in giving forth the discharge.

In another group of cases the tuberculous process shows a most decided destructive tendency. Possibly this may be due in some measure to the fact that the patient lives longer, more time being thus afforded for the destructive processes to work. It is more probable, however, that there are real differences in the types of the disease itself. The drum membrane undergoes complete destruction. The ossicles become loosened and disappear in the discharge, and later we are able to discover that the bone on the promontory wall is bare underneath the granulating tissues which cover it. The process indeed does not even stop here, that is, with the formation of a limited area of bone caries; but, instead, quite large masses of bone tissue die. Especially is this liable to be the case in children in whom there is a well-developed general tuberculosis. The sequestra thus formed are sometimes of extraordinary size, including wellnigh the whole petrous portion of the temporal bone as well as the wall of the external auditory canal. Such pieces are only rarely extruded by natural processes; usually operative measures are needed for their removal. The periosteum or dural surface, in the specimen pictured in the accompanying cuts, presented an entirely healthy appearance except at the spot where the bone has been sawed in two, as is shown in Fig. 1941. At this spot the periosteum was very much thickened and consequently must have served as a barrier to the invading forces trying to enter the skull from the middle ear. The bone was entirely gone in places, but the thickened subperiosteal tissues were good for a long resistance, and the meninges of the brain were perfectly healthy, although there was at one point—corresponding to the projection shown on the temporal bone—a depression which extended into the brain substance and into which the ball of the thumb could be easily inserted.

Fig. 1941 shows also the marked osteoporosis, *c* and *c'*, involving a large mass which includes the internal ear, *e*, and the auditory and facial nerves, *f* and *f'*, especially the former, which had been reduced to almost a pultaceous mass. Although death in this particular case was from pure asthenia, it could not have been long delayed, as a septic meningitis was imminent owing to the broken-down condition of the nerve tissues, as mentioned above. Such a meningitis occurred in another case the temporal bone of which I had the opportunity thoroughly to study. In this case I removed a specimen from a part where the roof of the tympanum was very thin, decalcified it, and cut it into sections. Except in those portions of sections where there were cheesy masses, I was disappointed in not finding by the miscroscope anything that was materially different from what we find in cases of rarefying osteitis, whether tuberculous or otherwise in its origin. In the deeper layers of the periosteum there was a certain amount of inflammatory tissue, and this was found to extend into the Howship's lacunæ and Haversian canals, arranging itself in layers and tiers of cells close to the bone proper. As will be seen from Fig. 1942, the osteoclasts seemed to sink themselves into the bone substance exactly as in other forms of bone decay. The impression which I gathered from studying these sections was that the only difference between the conditions here and those which are observed in simple rare-

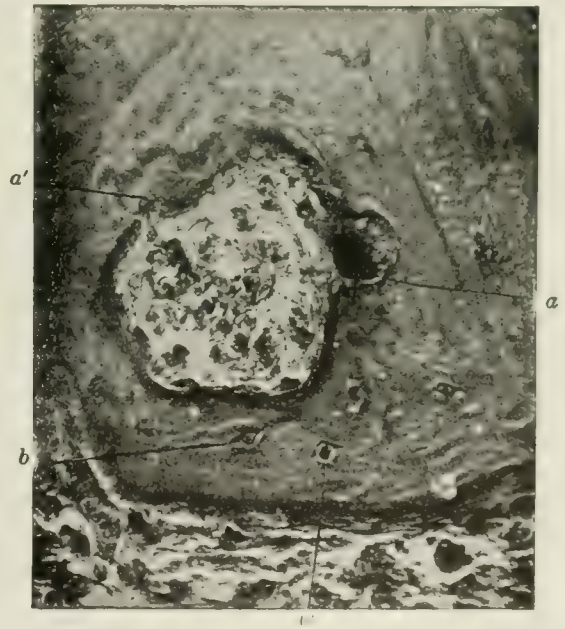


FIG. 1942.—Section through Decalcified Bone from Roof of Tympanum. × 1,000 diameters. (Original.) *a*, *a'*, Osteoclasts resting in a hollow which they had made in the bone substance *b*, *b'*, bone cells of the still intact bone. The manifest difference in size, as compared with the osteoclasts, is noticeable.

fying osteitis, is that the osteoclasts in the tuberculous form are perhaps a trifle larger than they are in the simple variety. In this case the tubercle bacilli were found back in the caseous tissue, where the coagulation necrosis was taking place, but were not discovered in

the actually inflamed area where we assume that phagocytosis is most active, the latter being nature's attempt to throw a barrier around the diseased tissue for the purpose of separating it from the healthy.

In the milder cases we have in the mucous membrane of the middle ear, as occurs in the larynx, ulceration and the formation of granulation tissue; these alterations, which are caused by other microorganisms than the tubercle bacilli, frequently yield readily to treatment. The other deeper lesions of the mucous membrane are found to have the giant cells and the coagulation necrosis as well as the tubercle bacilli.

This leads me to repeat the statement which I made in the earlier part of the article, viz., that the beginning of the trouble in the ear in many cases is probably simply a streptococcus or pneumococcus infection, and that it is only later that the tubercle bacilli get a chance to work out their full measure of mischief, the tissues being prepared for the latter by the previous inflammatory conditions.

Symptomatology.—When a tuberculous patient comes to consult the aural surgeon for relief of his ear trouble he relates that he had a feeling of fulness and discomfort in his ear for perhaps only a few hours or for a number of days, but that his attention was seriously directed to his ear only when, on arising one morning, he discovered that his ear had been discharging as shown by the presence of dried matter on the outside of his ear or by the staining of his pillow. He will relate, further, that since this particular occasion he had experienced no trouble beyond the fact that the discharge and the deafness had both continued to exist. The latter symptom is frequently much less marked than that which would accompany any other purulent otitis media. So significant is this quiet beginning of the disease that whenever a patient comes complaining of painless discharge and persistent though not severe deafness, I am at once suspicious that the underlying cause is a tuberculosis of the middle ear.

If an examination is made early in the progress of the trouble, one often finds more than one perforation. Quite frequently, I have seen these double perforations, but in no instance have I seen more than two. Troeltsch, however, records having seen on one occasion three. Multiple perforations are considered a sure presumptive sign of tuberculosis, and my own experience would lead me to place as high a value upon this piece of evidence as I would upon the presence of a pyriform swelling of the arytenoid cartilages of the larynx, or upon that of a dull apex of the lungs. These independent perforations persist for a shorter or a longer time and then merge into one large defect.

In carrying out the treatment of one of these cases of tuberculous disease of the middle ear the surgeon secures ample opportunities for observing closely the progress of events. Thus, for example, he will notice, in the milder cases, that after a certain period there ceases to be any further erosion of the drum membrane; the ulcerated edge retracts, folds backward, and is usually more or less overlapped by the granulation tissue which springs up from the promontory wall. Then, in a certain proportion of the cases, even when all local treatment is completely abandoned, the further formation of granulation tissue or of polypi ceases; in fact, such granulations may gradually shrivel up and the discharge become very scanty. Such partial spontaneous cures are not very uncommon. They remain in this state of comparative quiescence for varying periods of time; the patient finally dying without anything new of any importance having transpired in the middle ear.

In other cases the disease, from the start to the finish, pursues a very different course. In these cases, which belong to a more virulent type, and in which, after the destruction of the membrana tympani, the malleus and incus are exfoliated and washed out with the discharge at a comparatively early stage, the patients frequently complain that the ear is more or less painful and that there is a deep-seated boring; the discharge also becomes very foul-smelling, traces of blood are seen, and if one carefully cleanses such an ear and uses his probe with discretion he will easily discover that it passes through or between the portions of the granulating tissue and encounters bare bone. This bare bone sometimes is merely a simple caries of the bony wall of the middle ear and may be found in any portion of it, more frequently on the promontory wall—perhaps because it is more accessible—but it also occurs, as the probe will often discover, on the annulus tympanicus, on the roof of the tympanum, toward the mastoid, and even in the external canal itself. At a still later stage, in these progressive cases, it becomes evident to the medical attendant that he has to do with conditions of the ear such as are pictured in Figs. 1941 and 1942, *i.e.* with the formation of large necrotic masses and of sequestra. In children this will frequently progress in such a way that a little manipulation with the instruments or a little direct operative interference will disclose the fact that the masses are no longer attached to the healthy bone and consequently that they can be removed. Almost every aurist who has had more than a limited experience can recall cases in which larger or smaller masses have thus been removed either through the natural canal or by the various methods of laying open the ear from behind.

Occasionally, however, it transpires, as in the case from which the specimens which illustrate this article were taken, that the mass does not separate, does not give any evidence of loosening, and is so extensive as to deter one from even advising—in the weak condition in which these patients find themselves—any operative interference. In cases of this kind the infection which induces the terminal meningitis reaches the cranial cavity either by way of the roof of the tympanum, which breaks down and disappears, or by way of the labyrinth and internal auditory canal, after the destruction of the soft parts. The resulting meningitis in these cases is usually of the asthenic type. Gradually the patient succumbs to the slowly oncoming coma. He may have short attacks of dizziness and headaches from which he seems to recover entirely; later, however, he generally sinks into the comatose condition as into a sleep, and never regains consciousness. It very rarely happens that a patient, in a case of this kind, develops a brain abscess or any other intracranial affection than the basilar meningitis which produces the fatal termination. In the simpler cases, on the other hand, one rarely has to do, from first to last, with any pain or inconvenience, such as are quite commonly experienced by the patients belonging to the class just described.

Prognosis.—As already stated in an earlier part of this article, it is sometimes a very difficult matter, or even impossible, to prove, in any given case of extensive necrosis of the temporal bone, that we are dealing with tuberculous disease. Furthermore, the formation of these large sequestra in the temporal bone has been known to follow a severe attack of scarlet fever, without the interposition, so far as could be judged, of tubercle bacilli. Consequently, when one of these large masses is cast off spontaneously, or is removed by operative interference, and the patient gets entirely well again, it is hard to maintain, with any degree of confidence, that the case in hand was a genuine instance of recovery from extensive bone disease due to tuberculosis of the middle ear. I have myself observed only one case in which I felt confident that my patient had really recovered from an extensive tuberculous necrosis of the temporal bone. Under these circumstances, therefore, I am scarcely warranted in saying very much about the prognosis of the disease. That it is very grave, but not absolutely unfavorable, is all that the facts permit.

Diagnosis.—So much has already been said in various parts of the present article (in relation to the diagnosis) that it will suffice here simply to recapitulate the main points briefly. When the discharge is found, upon examination with the microscope, to contain tubercle bacilli, no further doubt can be entertained with regard to the nature of the disease. We are also warranted in feeling tolerably sure of our diagnosis when we find evidences, in other parts of the body, of the presence of tuberculous disease. The existence of multiple perforations in the membrana tympani, even when the presence of tubercle bacilli cannot be demonstrated, affords strong presumptive evidence of the tuberculous nature of the disease. The sluggish, asthenic type of the inflammation, the apparent ease with which bone caries develops, and the slight tendency of the tissues, or even the total absence of any tendency on their part, toward reformation of the parts destroyed, furnish additional and strong evidence of the tuberculous nature of the disease.

A word more with regard to the search for tubercle bacilli. If we were to follow up all our cases of middle-ear discharge by carefully staining for the microorganisms which are involved, I doubt not we should discover the tubercle bacillus where we never suspected it.

Treatment.—Under this latter head much or little might be said according to the view which is taken of the matter. It would seem perhaps better to consider first if there is anything for the tuberculosis which can be given as specific treatment *per se*. As changes in environment and injections of tuberculin either singly or together have been known to produce quite wonderful results in localized tuberculosis of other parts of the body—as for example in the larynx—it might be quite worth while to consider these in cases not too far advanced from either the local or the general standpoint. Regarding tuberculin injections, it is quite certain that in selected cases much might be perfectly safely accomplished by the use of very small and carefully strengthened doses, especially when this is done together with sensible and intelligent attention to the diseased tissues in the ear. Concerning local specifics, numerous experiments have been made in regard to tuberculosis of the ear, but, so far as I am able to judge, we have nothing for tuberculous disease in the ear which approaches being as nearly specific as lactic acid is for tuberculosis of the larynx. I have used this remedy by rubbing solutions of gradually increasing strength over the granulating surfaces in the middle ear, but have failed to get any better results than from other forms of careful treatment.

Iodoform has been recommended on account of the fact that it seems to act favorably upon tuberculous joints and bone tuberculosis in general. Perhaps it has some special usefulness in these cases, but I have not succeeded in obtaining specially favorable results. In view of the personal discomfort to the individual and to his environment which the use of iodoform always entails, and of the unfavorable results thus far obtained, I think it should never be employed.

Orthoform has been used in the advanced tuberculous cases in which the ulcerative process involved nerve trunks of sufficient sensitiveness to give more or less constant pain, and I have found that it acted, as it frequently does in the larynx, both to the comfort of the patient and to the cleaning up of the ulcerated surfaces.

The treatment then may be summed up under two heads: what the patient should do, and what measures the medical attendant should adopt. In mild cases in which the discharge is copious and the granulation tissue abundant, but without any involvement of the bone or any retention of large cholesteatomatous masses, the patient's portion of the treatment may be limited to the simple maintenance of cleanliness. A weak solution of carbolic or boric acid is to be syringed into the ear two, three, or four times a day, according to the amount of the discharge present. I have always found that the ear had less odor and was as a rule less offensive if, following the cleansing of the canal with an effective syringe, drops were instilled—as, for example, a solution of equal parts of glycerin and water containing one per cent. of zinc sulphate and two per cent. of carbolic acid. This simple astringent and antiseptic solution should be instilled warm into the ear.

In cases in which the granulation tissue seems to be abundant, equal portions of absolute alcohol and glycerin will be found to make an effective remedial solution for purposes of instillation. Before using this the ear should be very carefully dried out, as of course the effectiveness of this solution depends upon the hydrophilic properties of the materials employed. These instillations, if used at all, had better always follow the cleansing of the ear.

Peroxide of hydrogen is a much-used and in many quarters a much-lauded preparation, but it is more efficient when used by the physician himself than when given into the hands of the patient for daily use.

The physician who undertakes the treatment of a case of middle-ear tuberculosis should see the patient often enough to keep the granulations down, and if he succeeds in holding the disease in check, he has a right to believe that he is doing as well as can reasonably be expected.

It is only when the locality in which both physician and patient live possesses specially favorable climatic conditions that the former may hope to accomplish better results by the adoption of a more vigorous plan of treatment. Under ordinary climatic conditions, however, he should rest satisfied with the thorough cleansing of the ear; by which is meant that he should not merely syringe out the ear, but should also—by means of the swab and the curette, and by the use of the peroxide of hydrogen—remove all accumulations, of whatsoever nature, from every accessible place (more particularly the attic) where they may become lodged. After this has been accomplished, he should apply mild caustics to the granulating surfaces. If the latter are proliferating to such a degree as to produce polypoid masses, these should be removed by means of the snare of the sharp-edged curette. For simple stimulating purposes nitrate of silver, in strengths varying from fifteen to twenty per cent., will be found to answer well in this class of cases. Some authorities urge the necessity of using the stronger caustic preparations (chromic acid, nitrate of silver in the form of a solid bead) with great caution in cases believed to be of a tuberculous nature.

If the malleus is found to be necrotic, or the seat of a limited caries, this ossicle, together with all that may remain in the upper portion of the drum membrane, should be removed, in order that the freest possible drainage may be provided for the region of the attic.

Inasmuch as we can scarcely hope to do more than palliate the disease by the various measures which have been described above, and since it is further evident that even the most radical operative interference is not likely to be rewarded by materially better results, it is plainly our duty not to recommend these to this class of patients.

As regards the cases in which the tuberculous disease has produced such gross lesions as are shown in Figs. 1940 and 1941, it is not an easy matter to determine how far it is wise to proceed with surgical measures of a more or less radical character. Much will depend upon the condition of the patient's strength, whether he can bear the strain of the operation—and also upon the fact whether the sequestrum is or is not loose. If the patient's general condition is fairly good; if there are no evidences of meningeal, cerebral, or sinus involvement; and if the sequestrum appears

to be of not too large size and disconnected from the surrounding living bone, it is fair to expect that operative interference will place the patient in a more comfortable condition and will probably prolong his life. That it can accomplish anything toward curing the disease is not to be expected.

As is so often the case with the treatment of these and other cases of tuberculosis, we can best sum up the whole affair by saying that each case will have to be treated thoroughly and solely on its individual merits or *pro re nata*.

HENRY L. SWAIN.

**Eastport, Maine.**—Situated on the coast of Maine near the Canadian border, is a town of about 4,000 inhabitants. It is an attractive place, located upon a small island on the western shore of Passamaquoddy Bay. It is not known as a seaside resort, although it affords a cool summer temperature and facilities for fishing and boating. Its climate is representative of that of the northern New England coast, a cool summer marine climate—as indicated by the following table. Fogs are frequent as at most other resorts upon this northern coast.

CLIMATE OF EASTPORT, ME. LATITUDE, 44°, 54′; LONGITUDE, 66°, 59′. PERIOD OF OBSERVATION, APRIL 1, 1873, TO DECEMBER 31, 1883.

| Data. | January. | July. | August. | Year. |
|---|---|---|---|---|
| Temperature (Fahrenheit scale) — | | | | |
| Average or normal | 19.7° | 60.5° | 60.8° | 41.2° |
| Average daily range | 15.9 | 17.2 | 15.6 | |
| Mean of warmest | 27.6 | 69.6 | 68.9 | |
| Mean of coldest | 11.7 | 52.4 | 53.3 | |
| Highest or maximum | 51.0 | 86.0 | 88.0 | |
| Lowest or minimum | —20.0 | 45.0 | 45.0 | |
| Humidity— | | | | |
| Average relative | 77% | 78.7% | 78.9% | 76.3% |
| Precipitation — | | | | |
| Average rainfall in inches | 3.15 | 4.82 | 3.16 | 48.91 |
| Wind — | | | | |
| Prevailing direction | N. W. | S. | S. | S. |
| Average hourly velocity in miles | 12.4 | 6.3 | 5.9 | 9.7 |
| Weather— | | | | |
| Average number clear days | 7.1 | 5.2 | 8.0 | 78.7 |
| Average number fair days | 12.3 | 14.0 | 11 5 | 134.3 |
| Average number fair and clear days | 19.4 | 19.2 | 19.5 | 213 0 |

Three miles from Eastport in Passamaquoddy Bay is the picturesque island of Campobello which is a well-known summer resort with a cool and bracing climate.

EDWARD O. OTIS.

**Eaton Rapids Wells.**—Eaton County, Michigan.

POST-OFFICE.—Eaton Rapids. Numerous hotels.

ACCESS.—Via Michigan Central Railroad, or via Lake Shore and Michigan Southern. Twenty-five miles from Jackson, and seventeen miles from Lansing.

The town of Eaton Rapids is pleasantly situated on the Grand River. The wells were discovered in 1869 and 1870, and have drawn considerable attention to the place. Several of the wells are connected with the hotels, and all facilities for bathing are offered. The following analyses were made before the insertion of the first tubing, and it is probable that a considerable proportion of surface water was contained in that submitted for examination. The first three springs were analyzed by R. C. Kedzie and the fourth by C. T. Jackson.

| One United States gallon contains. | Bodine Springs, grains. | Mosher Springs, grains. | Shaw Springs, grains. | Sterling Springs, grains. |
|---|---|---|---|---|
| Sodium carbonate | | 5.38 | 11.57 | |
| Sodium bicarbonate | 5.05 | | | |
| Potassium carbonate | | 1.15 | 1.27 | |
| Potassium bicarbonate | 3.00 | | | |
| Calcium carbonate | | 19.43 | 20.74 | |
| Calcium bicarbonate | 40.47 | | | |
| Magnesium carbonate | | 4.52 | 3.84 | |
| Magnesium bicarbonate | 8.40 | | | |
| Iron carbonate | | | | 2.80 |
| Iron bicarbonate | 2.25 | 1.00 | 2.23 | |
| Sodium sulphate | | | | 12.59 |
| Calcium sulphate | 57.50 | 45.16 | 48.13 | 55.20 |
| Magnesium sulphate | | | | 9.40 |
| Sodium chloride | 1.50 | 0.90 | 0.90 | 5.21 |
| Silica | 2.00 | 2.54 | 1.40 | |
| Organic matter and Loss | | 0.85 | 0.90 | |
| Total | 120.17 | 80.93 | 90.98 | 85.20 |
| | Cu. in. | Cu. in. | Cu. in. | Cu. in. |
| Carbonic acid gas | 17.35 | 15.38 | 15.97 | |

EMMA E. WALKER.

**Ebstein, Wilhelm.**—One of the leading modern authorities on internal diseases and especially on obesity. He was born at Jauer in the province of Silesia, Germany, on November 27, 1836. He studied medicine at Breslau, under Frerichs, and afterward went to Berlin, where he followed the teachings of Virchow. He received his doctor's degree in 1859, and then for nine years he was connected with the Breslau Hospital. In 1874 he was appointed Professor of Medicine at the University of that city and Director of the Medical Polyclinic. Three years later

FIG. 1943.—Wilhelm Ebstein.

he accepted a call to fill the positions of Director of the Medical Clinic and Polyclinic and Professor of Medicine at the University of Goettingen, and he served in these capacities from that time until 1906. A few years before his death he was honored with the title of Geheimrat. He died on October 22, 1912, at the age of seventy-six.

Among the many contributions which Ebstein made to medical literature the following deserve to receive special mention: "Nierenkrankheiten nebst den Affectionen der Nierenbecken und der Urnieren," in the 2d edition of von Ziemssen's Handbuch der speziellen Pathologie und Therapie, vol. ix.; "Die Fettleibigkeit und ihre Behandlung," 7th edition in 1887; "Das

Regimen bei der Gicht," 1885; "Beiträge zur Lehre von der harnsauren Diathese," in Volkmann's Sammlung klinischer Vorträge, Leipzig, 1891 and "Zur Lehre von den nervösen Störungen beim Herpes Zoster etc.," in Virchow's *Archiv*, 1895. A. H. B.

**Ecbolics.**—See *Oxytocics*.

**Echinococcus.**—A genus of tapeworms which causes the hydatid disease. *E. granulosus* causes the cystic form of the disease; the minute adult lives in the intestines of dogs, jackals, and wolves; the cysticercus is found in man, sheep, ox, and pig. *E. multilocularis* causes alveolar or multilocular hydatid; the cysticercus is found in man, sheep, pig, but principally in large cattle. See *Cestoda*. A. S. P.

**Echinorhynchidæ.**—A family of *Acanthocephala* with elongated smooth body; the proboscis can be retracted into a sheath with double walls. There is a single genus, *Echinorhynchus*. *E. hominis* is a doubtful species, perhaps occurring in man. See *Nematoda*. A. S. P.

**Eclampsia Gravidarum.**—Definition.—The term eclampsia is quite generally employed to describe a symptom-complex marked by tonic or clonic convulsions which develop during pregnancy, labor, or the puerperium and are combined with a state of unconsciousness. The word has been rather unfortunately applied, for its Greek derivation refers primarily to the sudden onset of a single symptom, the convulsion, although this conception has gradually been extended to include the entire disease. It would be better if the term eclampsia were included as one of the several manifestations of the toxemias of pregnancy. In this article, however, we will limit ourselves to the term as usually understood and employed.

Etiology.—The fact that eclampsia has been described as a disease of theories shows the uncertainty which still attaches to its etiology. Before Lever discovered in 1843 the accompanying albuminuria, eclampsia was regarded as a uremic state, characterized by an intoxication of the blood through the retention of various substances, including urea, creatin, acid phosphate of potassium, and other urinary salts. As eclampsia was usually noted in connection with pregnancy and nephritis, it was likewise assumed that this disturbance was the cause of the retention of the various urinary constituents. During recent years cryoscopic examination has shown, however, that in eclampsia no specific retention of urinary constituents occurs. Although uremia has not been proved to be the underlying cause of eclampsia, subsequent experiments seem to have confirmed the theory that we are nevertheless dealing with an autointoxication, the nature of which probably resides in a disturbance of metabolism characterized by the retention of maternal or fetal toxic derivatives in the blood of the mother. These are probably colloidal albuminoids which under ordinary circumstances are converted by the liver into substances that should be excreted by the kidneys. For this reason it was held that an hepatic disturbance was the cause of the toxemia. Thus eclampsia of a renal or hepatic type has been described in which one or the other of these factors occupies the most prominent place in the clinical picture.

It has been conclusively shown that the urine of eclamptics is not, however, as toxic as the urine of normal pregnant women, but that on the other hand the blood serum of such cases is much more so than that of healthy subjects. It has also been assumed that the toxemia was due to the absorption of syncytial elements of the blood stream from the placenta. Again it was believed that it was not these *per se*, but rather the antibody or the syncytiolysin which poisoned the organism. Syncytiotoxin produced by the action of the syncytiolysin was next assumed to be the toxic factor which caused the convulsions. One of the most recent and interesting theories deals with a change in the character of the blood, the convulsions being supposed to be due to an acidosis or a decreased alkalinity of this fluid. In addition to the change in the reaction, an increased viscosity of the blood was also claimed to be an important factor in the production of eclamptic seizures. Another theory deals with the accumulation of toxic fibrin ferments and fibrinogen in the blood, especially in primiparæ, in whom the heart, liver, and kidneys have been reduced to relative insufficiency by the increased intraabdominal pressure. According to this theory the fibrin ferments produce convulsions and the fibrinogen results in a primary toxic tissue destruction involving the parenchyma of the excretory organs, principally the liver. Another interesting suggestion is that eclampsia possibly represents an anaphylactic reaction, according to which it is assumed that the pregnant woman is being constantly sensitized by small quantities of fetal protein but that if a larger quantity of fetal blood is suddenly drawn into the maternal circulation anaphylactic shock will result, which is considered identical with the eclamptic seizure.

Puerperal convulsions were explained a long time ago on the basis of a mechanical circulatory disturbance resulting in an edema of the brain, and a spasm of the renal vessels was likewise regarded as an important factor. This has been revived again in the theory according to which a reflex spasm constitutes a basis for the various clinical symptoms referable to the kidneys, liver, brain, and other organs. It is even claimed that the medium of a toxic substance is unnecessary to explain the phenomena of eclampsia but that a spasm of the arterial system, as yet unexplained, brings about changes in the nutrition and function of various organs, resulting in fatty degeneration, anemia, and necrosis. In a more severe degree this results in a sudden general disturbance marked by an increase in the blood pressure, exudation of plasma in the blood, hemorrhages principally in the liver, sudden cerebral anemia producing general convulsions or renal anemia with reduction in diuresis until the urinary secretion is completely suppressed.

Other organs have also been accused of providing an etiological factor in the production of the disease. Thus to the breast has been attributed a rôle in its production sufficient to lead several clinicians to advise immediate amputation of these organs in eclampsia or at least to direct therapeutic measures to the same.

On the other hand it has also been assumed that the fetus produces toxic substances, the retention of which results in eclampsia. A reflex vascular spasm which interferes with excretion from kidneys and liver has been likewise blamed for the retention. The liver and kidney degeneration which is commonly met with has also been ascribed to lactic acid production by the fetus and to the circulation of ferments which originate in the placenta. Insufficient synthesis and the maternal albuminoids derived from the syncytium are likewise considered as active toxic agents.

It is quite evident from the foregoing profusion of theories that we are still in doubt as to the exact etiological factors which produce eclampsia and the only positive information at hand is in regard to the characteristic lesions found at autopsy which include principally hemorrhages into the liver, brain, and other organs. Striking changes in the metabolism are undoubtedly present which lead to the production of a profound toxemia but whether this is produced by the maternal or the fetal organism or both we cannot as yet say.

Symptomatology and Clinical History.—It has been estimated that eclampsia develops in labor in about thirty-three per cent. of the cases, whereas in

fifty per cent. the convulsions appear during the eighth or ninth calendar months of pregnancy, and in perhaps fifteen per cent. the seizure develops after labor. Primiparæ are affected more often than multiparæ (about eighty-five per cent.) and very young and very old primiparæ or women with twin pregnancies seem especially predisposed. In the majority of cases an eclamptic seizure is preceded by certain premonitory symptoms for which a physician is unfortunately not often consulted. For some days or even weeks previous to an attack the patient may have noticed an increasing swelling of the feet, the hands, or the face, accompanied by constipation and a diminution in the urinary secretion. During the same time there is usually observed headache, nausea or vomiting, epigastric pressure, severe abdominal pain, vertigo, tinnitus, visual disturbances, and occasionally a greater or lesser degree of actual blindness. Examination of the urine at this time usually reveals the presence of albumin and occasionally of casts, together with an increase in the specific gravity. If recognized and treated at this stage the further progress of the disease may be halted and pregnancy proceed to a normal ending. Otherwise, and sometimes even notwithstanding treatment, the condition progresses and may be said to follow two different types. In the commonest we find recurring convulsive seizures which may come on without any further warning and are interspersed with periods of partial or complete coma. In the other variety a gradual deepening coma may be the only outward evidence of trouble. A typical eclamptic convulsion may come on with or apparently without the warning signs just referred to in women who are seemingly in perfect health. Careful questioning in these cases usually reveals the presence of the prodromal symptoms described. The convulsive movements usually begin around the mouth and then involve the remaining muscles of the face. The extremities are next affected, beginning with the smaller groups of muscles included in the hands or feet and extending up the arms or legs until the entire body is involved in a tonic or clonic seizure. During this time the breathing is stertorous, the face flushed or congested, foam is present in the mouth, often blood-stained because the patient commonly bites her tongue. The seizure may last for a few seconds or several minutes and is succeeded by a period of profound unconsciousness. The coma which follows lasts for an indefinite period and although some cases may have only a single convulsion, others have many with gradually decreasing intervals between them. An increasing number of cases are being reported with an entire absence of convulsions, although when the patient finally succumbs, the autopsy findings are similar to those in the other class of cases.

A marked increase in the blood-pressure reaching 240 to 260 millimeters is usually noted. The pulse is full and bounding at first but in the severe cases becomes weaker and more rapid as the disease progresses. In some cases where the blood-pressure is lowered by poor resistance, convulsions do not occur, although these cases often end fatally. There may be a rise in temperature although as a rule this remains normal.

If the convulsive seizure comes on before labor the pregnancy may be terminated in various ways. If the patient is left alone or treated expectantly, and particularly if the child is premature, labor may be spontaneous and is usually rapid. In some cases labor does not come on but the woman apparently recovers and may give birth to a dead or living child some time afterward. It would seem as if the life or death of the fetus was of no particular importance as an etiological factor in the disease. If the seizure comes on during labor the force of the latter is usually increased. In severe cases, however, or where there is dystocia present, the patient may die undelivered unless operative measures are employed.

In postpartum eclampsia the condition may subside after the first convulsion or it may get progressively worse and this form of the disease is practically as fatal as the others, a mortality of about twenty-five per cent. resulting.

Suppression of urine may be absolute although in all cases the amount is reduced and the specific gravity raised. Casts of every type may be found. The amount of albumin in the urine varies from ten to forty grams per liter, but this is only temporary and subsides soon after delivery. It has been shown that the total nitrogen output in the urine is markedly diminished and that the urea constituent is reduced from four-fifths to less than one-half. The amino-acids, creatin, uric acid, etc., are relatively increased. Although indicanuria is usually present it must be regarded merely as a symptom of a toxemia and is not associated with any definite pathological condition. It serves as an indicator of the absorption of bacterial putrefactive substances from the intestine.

The after-effects of eclampsia are varied. Hemianopsia has been noted during the puerperium but more frequently we find an albuminuric retinitis which may be ascribed to an acute nephritis. In other cases, however, a purely toxic factor may be at the basis of the visual disturbances and no atomical changes can be noted in the eye itself.

Pulmonary edema is a frequent accompaniment of the severer types of the disease and should be guarded against as much as possible by refraining from keeping the patient in a constant prone position. Examinations of the chest should be made at frequent intervals for several days after the seizure and appropriate treatment instituted as soon as evidences of pulmonary edema appear. Septic pneumonia is not unusual as the result of inspiring foreign material during the seizure. If this complication occurs it renders the prognosis very much more grave. Puerperal psychoses are not uncommon after eclampsia and the patient's mental condition should therefore be carefully watched as long as two or three weeks after recovery has apparently taken place. As the result of a necrosis of the mucous membrane of the stomach profuse gastric hemorrhage may result.

The relations between the eclamptic seizure and labor are important. Labor results in most of the cases probably because the blood becomes overloaded with carbon dioxide. The latter is also frequently the cause of the death of the child.

Pathology.—Notwithstanding the intense interest which attaches to this subject and the constant efforts to explain the etiology of the disease, no definite conception of the pathology of eclampsia has been formulated. Because albumin was found in the urine it was long believed that a nephritis was the essential pathological lesion, until it was shown that only a small proportion of women who had chronic Bright's disease also had eclampsia and moreover that eclampsia frequently occurred without the presence of an albuminuria. Renal lesions of an acute inflammatory type with degeneration and necrosis of the epithelium and often accompanied by hemorrhages, mainly of a subcapsular form, are almost invariably present, but at the present time they are no longer considered characteristic of the disease. Hepatic changes have now assumed a much more important rôle. These consist principally of areas of necrosis involving the periphery of the individual lobules and the portal spaces, in addition to hemorrhages under the capsule. Edema of the brain has been noted in over forty per cent., hyperemia in thirty-five per cent. and apoplexy in thirteen per cent. of a large series of collected cases, in which ten per cent. of those examined were apparently normal. Thrombi in the small cerebral vessels are frequent and the hemorrhages noted may vary from those of small extent in the pons to very much larger ones which

distend the lateral ventricles. Heart lesions are frequently observed and usually consist of myocardial degenerations, although it has been claimed that in some cases they are due to chloroform poisoning where this substance has been employed as an anesthetic. Minor pathological lesions of various types have been described including masses of syncytial cells in the pulmonary capillaries and lesions associated with bronchopneumonia or evidences of puerperal infection. It is quite evident that apart from the changes in the liver no specific pathological lesion has been found in this disease and there is a marked discrepancy in the statements made by various authors as to the relative frequency and importance of the lesions referred to. In a large number of cases, however, the hemorrhagic processes attract attention to the fact that evidently one important factor in the morbid process consists of the presence in the circulation of a toxic substance which exerts a solvent power or a deleterious influence of some kind on the endothelial lining of the blood-vessels. Thus far, however, the pathological findings afford us very little help in directing the treatment of the disease.

Diagnosis.—Although the diagnosis of eclampsia is usually made on the basis of convulsive seizures with loss of consciousness, similar phenomena due to an epileptic or cerebral origin must not be forgotten. Epileptic seizures may occur during labor but the recovery is rapid and there is usually a history of previous attacks. Convulsions due to cerebral lesions are usually accompanied by paralysis and in the presence of a meningitis there is always a rise of temperature noted. Moreover, in both of these conditions the urinary symptoms noted in eclampsia are absent. Hysterical convulsions are not accompanied by any loss of consciousness. If eclampsia without convulsions is present, the only other condition to be thought of is a uremia and in this instance an immediate differential diagnosis is quite unimportant because the early treatment in both is essentially the same.

Prognosis.—The maternal mortality in eclampsia, according to the most recent statistics, is about twenty per cent. When the attack comes on before labor the mortality is increased mainly because this process adds its own factor of danger. The prognosis depends somewhat on the nature of the attacks and their severity, although recoveries have been reported after a very large number of seizures. In other cases a single convulsion may be accompanied by a fatal cerebral hemorrhage or a pulmonary embolus. When the seizure comes on during or near the end of labor the convulsions usually stop with the birth of the child and the final outcome is ordinarily very good. In every case, however, the prognosis must be guarded until at least a week has elapsed after beginning recovery. The mortality among the children is very large, most statistics stating this to be at least fifty per cent., although with the more modern methods of delivery a very much larger number of infants have been saved. The life of the child should ordinarily not be taken into consideration, for although born alive it often succumbs within the next few weeks to the deleterious effects of the intoxication to which it has been subjected.

Treatment.—The uncertainty as to the etiology of eclampsia has resulted in much disagreement regarding the best methods of treatment. On the one hand we meet with the conservative attitude in which medical measures occupy the foreground and on the other hand the more radical position of those who depend entirely on purely surgical procedures in the treatment of the condition. It will be convenient to consider the therapeutics of eclampsia as directed to the prophylaxis, to the treatment of the convulsive stage, and to the period of recovery.

The *prophylactic treatment* of eclampsia is applicable to that period which has already been discussed under "prodromal symptoms." If the latter are recognized by the patient in time and brought to the attention of the attending physician, much can be done to ward off the more serious stages of the disease which are likely to follow. Treatment at this time consists largely of eliminatory procedures directed to the skin, the kidneys, and the bowels, no direct notice being taken of the pregnancy itself. If a patient during the latter months of pregnancy complains of rather persistent headaches, attacks of dizziness, nausea, and visual disturbances, accompanied by a diminution in the amount of urine excreted, constipation, and swelling of the hands, feet, or face, the following régime should be instituted. Calomel, gr. i.–v., with bicarbonate of sodium in proportionate amounts, should be given in divided doses, followed in from six to twelve hours by a saline cathartic, either Epsom or Rochelle salts or one of the natural saline mineral waters. At the same time the patient should be directed to abstain from all food while taking the calomel and afterward to subsist entirely on milk in any desired form, cereal gruels, with bread or crackers, and plenty of water. Meat, soup, tea, and coffee should be interdicted. In view of the sudden onset of the more serious convulsive stage of the disease, such patients should be directed to take an enema immediately, before beginning the other treatment, so as to make certain that the lower bowel is emptied. An examination of the urine should also be undertaken and particular attention paid to the tests for albumin, acetone, diacetic acid, and indican, in addition to noting the amount passed in the twenty-four hours and the specific gravity. If greater attention were paid in the analysis of the urine of these patients to the presence of the products of intestinal decomposition and the specific gravity, rather than to the presence of albumin, a smaller number of severe cases of eclampsia would result. After the initial dose of calomel the patient should be given cathartics continuously until the symptoms have cleared up and the diet should remain as noted for the same period. Elimination from the skin may be maintained by warm baths (taken once daily) at a temperature from ninety to one hundred degrees Fahrenheit, depending on the individual's idiosyncrasy. The bath water and the time of immersion should be guided by the readiness with which a gentle perspiration is induced. After the bath the patient should go to bed and remain warmly covered for several hours. Diuresis may be aided at this time by the ingestion of a glass or two of water before immersion in the bath. The cathartics which are indicated during the after-treatment of this period include fluid extract of cascara in doses of from ten to thirty drops three times a day after meals, or salines in the early morning, particularly in women inclined toward obesity. Patients who have developed such prodromal symptoms should be carefully watched throughout the remainder of their pregnancy and any recurrence of their symptoms must be immediately treated as before noted. The fetal heart should be auscultated at frequent intervals and if the symptoms do not improve and the patient notes a diminution in the fetal movements, gradual induction of labor may be considered, particularly if the patient is near term. At any rate the day of the prospective labor should be carefully calculated and the growth of the fundus watched so that the patient may not go over time and develop a large fetus which will increase the difficulty of her labor and thus add to the chances for a sudden convulsive outbreak.

*Treatment of the Attack.*—If we are dealing with an eclamptic seizure the method of treatment is different. In view of the divergence of opinion already referred to and the good results obtained by those who adhere to a middle course in the treatment, a plan of this kind will be described herewith. In

every case of eclampsia we must consider the patient rather than the disease and modify our treatment accordingly. Thus it is not fair to say that every case of eclampsia must be treated by either purely medical or purely surgical measures but we must take into consideration the symptoms as presented by the individual case. Nevertheless in view of the theory generally accepted that eclampsia is a form of toxemia, the origin of which has not as yet been determined, we are justified in applying those eliminative and sedative measures which would be called for under similar conditions outside of pregnancy. The pregnant uterus constitutes an incidence in a disease which involves the entire maternal organism, likewise that of the fetus. Before proceeding to a further discussion of the treatment, attention is called to the fact that every case of threatened or actual eclampsia should be sent, if possible, to a hospital, as the treatment of the same can be carried out much more satisfactorily under such surroundings. Preliminary to this, however, the attending physician can do a number of things which will favor greatly the recovery of the patient. The appearance of convulsions is usually productive of great excitement on the part of the patient's family. This unfortunately often involves the physician who feels that he must do something immediate and radical. The appearance of a single convulsion should not, however, serve as an indication for immediate operative delivery, such as a vaginal or abdominal cesarean section. The convulsion is merely a single symptom of a severe general toxemia and the shock of such operation greatly adds to the patient's danger. The entire nervous system of the woman at this time is in a most unstable condition and the disturbance in the cerebral circulation is such that not only evidences of cortical irritation such as the familiar convulsions are present, but hemorrhages are liable in any part of the brain. The first thing to do, therefore, is to insure absolute rest, which reduces the tendency to convulsions, and then to relieve the arterial spasm which is a factor in the production of further convulsions and fatal hemorrhages. The patient should therefore be placed on her back in a darkened room which is kept warm and free from noise although liberally supplied with fresh air. The clothing should be removed at once and the patient subsequently handled as little as possible. A hypodermic injection of morphine, one-quarter to one-third of a grain, is recommended for its general sedative effect. It has been customary in the past to employ chloroform for the convulsions, but as this drug undoubtedly favors fatty degeneration in both kidneys and liver, its administration had better be omitted. Moreover, if given during the attack, very little is actually inhaled because the patient holds her breath at this time, and the deeper inspirations which follow as the convulsion ceases may cause the woman to inhale very much more than is good for her. A soapsuds enema, repeated if possible, should be given as soon as the opportunity offers, and as soon as the patient recovers consciousness after the seizure, from four to six ounces of a hot half saturated solution of Epsom salts should be given by mouth. Croton oil in drop doses placed on the tongue, elaterinum, and other drastic cathartics have been recommended, but as they are not easily procured and administered, their employment as a routine is not advised. As soon as the patient has shown the quieting effect of the morphine, a vaginal examination is to be made under as careful aseptic precautions as possible and the condition of the cervix and the presenting part noted. If a dilatation of more than three fingers is present, the membranes may be ruptured, as this relieves immediately the intraabdominal tension. While this is being done steps must be taken to favor elimination from the skin. The patient should be wrapped up in blankets wrung out in hot water of a temperature of at least 120° F. and kept in the same until perspiration becomes free. These hot packs may be continued for periods of one-half hour or more and repeated every two or three hours as the case may demand. Rectal irrigations are very effective in aiding elimination in some of these patients, but we must be guided by the factors present in the individual case before administering them. If considerable edema is present it is not advisable to introduce any more fluid into the system and it is better therefore to delay the irrigation until some of this fluid has been drained away through the bowels and skin. The action of the kidneys is stimulated, however, by hot colonic irrigations and, after the bowels have been thoroughly cleaned out with enemas and the hot pack administered, a continuous irrigation with four gallons of normal sugar solution may be given through a rectal tube attached to a fountain syringe which is held about two feet above the patient's head. Sugar solution, a flat teaspoonful to the quart of water, is preferable to the usual salt solution, as being less irritant to the kidneys. If the woman is turned on her left side the flushing of the colon will be very much facilitated. These irrigations may also be given while the patient is wrapped up in the hot blankets after the pack, if undue exposure can be avoided. If no further convulsions occur and the patient remains quiet and reacts to the other measures stated, it will not be necessary to administer any further sedatives, otherwise one-eighth of a grain of morphine by hypodermic may be given in an interval of one or two hours after the first injection or from fifteen to twenty grains of chloral by mouth or from twenty to sixty by rectum may be employed. The blood-pressure should be watched in all cases and as the physical measures referred to have a tendency to reduce the same it may not be necessary to administer arterial dilators. When necessary, nitroglycerin in doses of one-fiftieth of a grain by hypodermic, repeated every twenty or thirty minutes until the blood-pressure begins to subside, is the most efficient drug which can be used for this purpose. Veratrum viride has been recommended and is still largely employed in general practice, but the reduction of the blood-pressure is so extreme and so difficult to control that the administration of this drug is accompanied with some danger. If given, the best preparation for the purpose is the so-called Norwood's tincture, which is administered in doses of fifteen minims (twenty-five drops) or 1 c.c. by hypodermic injection and repeated every hour until the pulse is reduced to sixty a minute or less. If within this time the rate diminishes to one hundred per minute, only ten drops of the tincture need be injected in the succeeding dose. According to those who have employed this method, not more than two or three full doses are necessary to bring the pulse down to sixty.

The extracts of the thyroid and parathyroid glands of the sheep have been recommended for the treatment of eclampsia because they are claimed to destroy metabolic and other poisons and have a diuretic action. The utility of these preparations still awaits further demonstration. In order to guard against injury to the tongue during the convulsion, the handle of a wooden hair-brush or similar contrivance should be inserted and held between the molar teeth. No force should be employed in restraining the patient during the seizure as this merely increases the liability to a continuance of the spasm. It is only necessary to keep the patient prone and remove the clothing as soon as possible.

Oxygen inhalations are of undoubted value during and between convulsions as an aid in overcoming a possible asphyxia from impeded respiration and also after operative interference, to stimulate the heart and respiration. Washing out the stomach is advisable if the attendant is sufficiently skilled and prepared to do this, otherwise the danger of injuring the pharynx

or the possibility of getting foreign material into the respiratory tract contraindicates the procedure.

A natural result of an eclamptic seizure is the induction of labor for reasons stated earlier in this article. If an examination discloses that delivery may be readily accomplished without shock or injury to the mother this can be carried out. The cervix, if dilatable, may be stretched by Harris's method, or if the case warrants, soft rubber dilating bags may be employed. Simple cervical incisions may be employed in a rigid cervix of not less than three and one-half fingers' dilatation, the membranes ruptured and labor completed by forceps or version. Other operative procedures should not be undertaken in the patient's home, although it is claimed for vaginal cesarean section that it may be done under such circumstances. If it is found that the cervix is elongated and has not undergone any softening, either a vaginal or abdominal cesarean section may be considered, if no response follows a thorough trial of medical measures. In every case the individual factors which are present should be carefully considered. In a woman at the seventh or eighth month the chances of obtaining a living child are very much reduced, as the fetus suffers from the same intoxication which affects the mother. Radical operative procedures usually reduce the chances of survival to a large extent and the resultant premature baby may not live more than a few weeks. As already stated vaginal cesarean section offers a ready means of delivery during the seventh or eighth month. Notwithstanding the apparent ease of its execution such a serious operation should not be attempted except in a hospital with skilled assistants or unless these conditions can be duplicated in the home. Operative delivery by this means can be carried out readily and quickly enough but much difficulty may be found in suturing the lower uterine segment subsequently and the danger of laceration to the maternal soft parts is also considerable. Stretching the perineum manually is advisable before this procedure. It is probable, however, that the hemorrhage which takes place during such an operation is a very important factor in affording relief to the patient. If the patient is at or near term an abdominal cesarean section may be considered in these cases as of equal if not greater value than that conducted by the vaginal route, particularly if the child is large or a twin pregnancy is present, combined perhaps with some variety of pelvic contraction. As the liver and kidneys are both the seat of degenerative processes at this time, their immunizing activities are necessarily diminished and puerperal infection in eclampsia is liable to occur, particularly in operative cases. The cathartic measures advised in treatment likewise add to the same and care is therefore necessary to avoid contamination from this source.

Anesthesia must always be conducted under the most careful auspices to avoid further damage to the kidney or the production of a pneumonia. Gas and oxygen are contraindicated because the blood-pressure is already high, chloroform predisposes to parenchymatous degeneration and heart failure, while ether, preferably by the drop method, presents perhaps the least number of disadvantages. If morphine has been previously administered, the amount of ether required will be greatly reduced.

One measure which may be considered surgical is the abstraction of a certain quantity of blood from the patient's veins. This method of treating eclampsia without resort to immediate delivery has come into vogue very largely during recent years, and undoubtedly a reduction in the amount of toxic blood circulating through the patient's vessels is of great value. A vein in the arm should be chosen for the phlebotomy and from eight to sixteen ounces of blood allowed to flow through a canula if possible. The quantity abstracted must depend on the physical condition of the patient, a larger amount being allowed to escape from a plethoric woman than from a small, poorly nourished subject. If an operative delivery is planned, caution in venesection is indicated, as the hemorrhage necessarily accompanying the operation may be difficult to control and the combined loss of blood may greatly increase the shock of the patient. A high blood-pressure in a well-nourished woman presents the most favorable indication for phlebotomy.

The treatment of those cases of eclampsia in which convulsive seizures are lacking is essentially the same, as we are dealing here with a similar accumulation of toxic material in the system which requires elimination. The absence of convulsions makes it unnecessary to administer sedatives to these patients as a generul rule, unless to relieve restlessness.

*After-treatment.*—It is essential to watch every case of eclampsia for several weeks after the actual symptoms have subsided. If the pregnancy has been allowed to continue such patients should be kept on a diet as free from protein material as possible. The bowels should be emptied by simple cathartics and enemas, the function of the skin should be stimulated by hot baths and the patient kept as free from excitement and external irritation as possible. Very frequently such women will go on and deliver themselves by a natural labor in the course of the next few weeks. The child is often dead in these cases, and if this fact can be definitely determined labor may be induced by the accepted means. The condition of the kidneys must be carefully observed and as permanent damage to the same may result, the precaution should be taken to examine the urine frequently, further treatment being governed by the symptoms as in any other case of nephritis. The various complicating lesions, such as hemiplegia, visual disturbances, psychic aberrations, etc., must be taken care of in the usual manner.

The question as to whether an eclamptic patient should nurse her child is by no means settled. According to theories recently proposed the colostrum of such women is highly toxic and a variety of procedures, from merely emptying the breasts to a complete amputation of these organs, has been advised. It is probable that the toxicity of the mammary secretion is merely due to the fact that the breast is involved in the general eliminative processes. If the breasts are full there is no objection to emptying them with the ordinary breast-pump and if a living child has been delivered this may be readily fed by other means for the first day or two. Nursing should not be resorted to until the mother has fully recovered from her coma and the urinary secretion has been re-established. As a general rule the child does not appear to be affected by the milk of a mother who has had eclampsia.

An infant born of an eclamptic mother may likewise develop convulsions of a greater or lesser degree during the first week or two of its existence. Quite frequently these manifest themselves as contractions of one or more limbs, a spasm of the muscles of the neck, or of the eyes, producing a squint. Hot mustard baths, colonic irrigations with normal sugar solution, the administration of sterile water, and artificial feeding are usually all that can be done in such cases.

In summarizing the treatment of eclampsia it is becoming universally admitted that the best plan is to be governed entirely by the symptoms presented by the individual patient. No specific treatment for the disease has yet been discovered. Prophylaxis is a very important feature. Patients should be warned as to the significance of the prodromal symptoms of the disease. When these are present they should be combated by the means already referred to. In the event of a fulminating attack, sedative and eliminative measures as already described, combined with operative interference only under certain indications, seems to afford the best chances for the mother. The

life of the child in most of these cases cannot be taken into consideration. Although it is desirable in most instances to empty the uterus, if done it should be carried out with the least shock to the mother and regarded as only one factor in the successful treatment of the case, the other measures referred to being of equal importance.

The bibliography of eclampsia is too extensive to permit of detailed references to the same in this connection. Acknowledgement is made to the writings of the following authors whose publications have been consulted in the preparation of this article: J. W. Williams, De Lee, Dührssen, Lichtenstein, Liepmann, Stroganoff, E. P. Davis, Bailey, R. Petersen, Dienst.

GEORGE W. KOSMAK.

**Eclampsia Infantum.**—*Synonyms:* Convulsions in children; acute infantile epilepsy; spasms.

By eclampsia in children is meant a variety of convulsions, more or less general, occurring with or without prodromal manifestations, and not dependent upon any material organic lesion of the nervous centers. Most authorities regard absolute abolition of consciousness as an essential element of eclamptic as well as of epileptic attacks. This loss of consciousness need not persist during the whole attack, but must have occurred at some part of it. It is true that there are attacks of very slight spasms in children in which it is difficult to be positive that consciousness has been lost, by the application of such imperfect tests (irritation of the conjunctivæ, etc.) as these little subjects will admit; but analogous attacks in adults prove that loss of consciousness, however brief, is an essential element of an eclamptic convulsion. An important point in the differential diagnosis between an attack of eclampsia and one of epilepsy is that in the former the convulsions are not repeated in a series. It is true, attacks of eclampsia may be repeated, but unless the repeated attacks can be shown to have depended upon one or other of the conditions which ordinarily give rise to eclampsia, every repetition of the convulsion renders our suspicion as to its epileptic character stronger.

In describing an eclamptic seizure, it is important to remember that the convulsion differs in no way from an attack of epilepsy. Hence a general clinical picture of the disease will be that of an ordinary epileptic spasm. There may be an aura, a cry, then convulsive movements in some of the voluntary muscles, proceeding rapidly to more or less general convulsions, at first tonic, then clonic in character. There is loss of consciousness, generally, before the tonic convulsions have set in; the little patient may froth at the mouth, the tongue may be bitten, the respiration is that characteristic of epileptic attacks; finally the spasm is often followed by sleep. It is evident, then, that we must not depend upon the character of the convulsion for a differentiation between epilepsy and eclampsia, although a careful study of the clinical history of the case will generally give us the data necessary to a correct diagnosis.

CLINICAL OCCURRENCE.—Nothnagel[1] and Ozanam[2] discuss the possibility of the occurrence of eclampsia infantum as an idiopathic affection. The latter authority limits the term eclampsia to convulsions of non-epileptic origin, occurring independently of other diseases or pathological conditions. Nothnagel, however, includes under the term eclampsia convulsions which are the reflex expression of some peripheral irritation, such as dentition, etc. The convulsions occurring at the outset of acute infectious diseases and acute inflammations he terms simply epileptiform, a term that might be applied to all varieties of eclamptic attacks. Eclampsia infantum should be considered not so much a disease as a symptom of other diseases; in one case the convulsion may only precede or usher in a pneumonia, in another it may appear at the same time with a brilliant scarlatina; here dentition appears to have been the exciting cause, there the ingestion of indigestible food; in all of these conditions the attacks resemble each other, although in each case the clinical etiology is different. Looking, then, upon eclampsia from an etiological standpoint, it appears that all the possible conditions under which eclamptic attacks may occur in children will come under one of the following subdivisions:

1 Febrile or symptomatic eclampsia.
2 Reflex eclampsia.
3 Toxic eclampsia.
4 Eclampsia of rachitis.
5 Eclampsia in infants and young children as a manifestation of spasmophilia.

*Febrile or Symptomatic Eclampsia.*—The most common form of eclampsia occurring in young children is undoubtedly the first group, the febrile or symptomatic eclampsia. By this class is meant that form of eclampsia which occurs, as a rule, at the *outset* of febrile diseases; we say at the outset, to distinguish these initial convulsions from those occurring later on in the course of severe inflammatory conditions, and due not so much to the fever as to cerebral adynamia, or the aggregation of toxic elements in the blood as a result of the disease. So commonly does a convulsion mark the outset of inflammatory disease and acute infectious fevers of infancy, that it would almost appear that in these little patients the eclamptic seizure corresponds to the chill which ushers in similar diseases in adults and grown children. This substitution of a convulsion, an eminently nervous phenomenon, for a chill, corresponds to the exalted irritability of the nervous system characteristic of infants. This excess of irritability is especially marked in the medulla oblongata; and since the studies of most observers, among others Schroeder van der Kolk,[3] point to the medulla as the starting-point of the changes resulting in an epileptiform convulsion, the increased liability to convulsions at this early age is readily explicable. How shall we explain the occurrence of this febrile form of eclampsia? Is the convulsion due to the fever, or to some mysterious infection of the blood by the poison of the disease of which the fever is a symptom? Authorities differ as to this point, the tendency being to individualize and explain the occurrence of the eclampsia in distinct ways for different diseases. In the first place, in inflammations of the brain and meninges the convulsions are not eclamptic, being dependent upon a material lesion of the nervous centers. But the eclampsia introducing an attack of pneumonia, pleurisy, measles, or scarlet fever, how is this produced? Steiner[4] considers the convulsions which precede an attack of pneumonia as the reflex result of the irritation of the peripheral filaments of the pneumogastric distributed to the congested lung. The weakness of this explanation does not lie in the fact to which Soltmann[5] calls attention, that eclamptic convulsions do not occur in all cases of pneumonia in children, but rather in this, that the convulsions are not so frequently repeated as we should expect were this theory true, for the lung remains congested during many hours, while the convulsion lasts but a few minutes, and in many cases is not repeated. We do not think that any further explanation of the eclampsia of the early stage of pneumonia need be given than that it is due to the high temperature which ushers in the disease. The rapid and bounding pulse, characteristic of the febrile process, produces cerebral hyperemia, the already over-excitable medulla is rendered more excitable, and a convulsive discharge of nerve force takes place; the cause here is evidently simply increased temperature, and its recognition serves as an important indication for treatment.

In the acute infectious diseases, one might readily be excused for supposing that the initial convulsion is most probably due to the altered condition of the

blood. The microorganisms of scarlet fever, as well as those of measles and diphtheria and other infectious diseases, may well have so changed the blood, even in the opening stages of the disease, as no longer to enable it properly to nourish the nerve centers; accordingly such writers as Soltmann[5] and Henoch[6] consider that the eclampsia, even in the onset of these diseases, is mainly due to the toxemia; and yet these convulsions frequently do not occur in the most severe cases, and do occur in the mild ones. The toxemia must be regarded as varying in direct proportion to the severity of the affection and the same should be true of the convulsions to enable us to accept the view of Henoch. We do find, however, that in most of the cases in which convulsions have occurred the temperature was very high, irrespective of the severity of the disease. I recall a case in my own experience, similar to one reported by Hunter,[7] in which, with the onset of a varicella, the temperature rose to 105° F., and the child had two eclamptic convulsions; on the succeeding day the temperature had fallen and the little patient was able to run about in the room. One can cause the cessation of repeated eclamptic attacks in a case of commencing infectious disease by the application of a cold bath. For these reasons it would appear that in these cases also the active cause of the convulsion is the increased heat of the body. It must be acknowledged, however, that there are cases in which the specific toxemia of the disease is so great that the nervous centers are completely overwhelmed. In these cases the convulsions are really toxic in character, and are far more fatal than those depending upon the fever; here, too, we shall often find upon postmortem examination inflammatory disturbances of the brain and spinal cord. In the vast majority of cases of eclampsia occurring early in the course of infectious diseases, reduction of temperature will result in cessation of the convulsions. The diseases in which this febrile form of eclampsia may occur include almost all of the febrile affections of childhood, that is, all of the acute infectious diseases, among which must not be forgotten erysipelas and typhoid fever; also all of the inflammatory affections of the respiratory organs, such as laryngitis, bronchitis, pleurisy, and pneumonia; and the acute catarrhal, croupous, and diphtheritic affections of the throat and pharynx. Febrile eclampsia, although more frequent at the outset of febrile diseases, may occur later on in the course of these diseases. As already stated, the eclampsia then occurring is, as a rule, dependent upon blood changes; but not necessarily, for although the nervous system of the child seems to become habituated to mere elevated temperature, yet a great and sudden rise of the fever at any stage of the disease may produce a convulsion. Thus, I have seen a convulsion occur in a child suffering from a pneumonia on the evening before the critical day, the convulsion being simultaneous with the highest rise of the temperature curve.

Malarial fever, according to many authorities, frequently has the chill which ushers in the paroxysm in adults, replaced, in children, by a convulsion.

Malarial eclampsia, so called, is most frequent in infants under three years of age suffering from intermittent fever. In older children the convulsion is absent while the chill is present. When the convulsion takes the place of the chill it is said to be exceedingly severe and may last for hours; sometimes each recurrence of the malarial paroxysm is accompanied by a convulsion. Dubirsay[8] reports a case in which the convulsion recurred with eleven distinct malarial paroxysms. These convulsions are probably toxic in character.

Parotitis, when accompanied by high fever, may be an etiological factor in the production of an attack of eclampsia. Dysentery, gastritis, cholera infantum, all of these when accompanied by high fever may produce a convulsion. Here again, however, we must distinguish the febrile convulsions from those which occur in the later stages of these diseases and are dependent upon the cerebral vascular changes, of which the depressed fontanel is so characteristic a symptom. In conclusion, it may be said that any affection accompanied by high fever may result in an eclamptic attack in infants.

*Reflex Eclampsia.*—By the term reflex eclampsia, which is the second subdivision under which we shall discuss the subject, we mean that form of eclampsia which is the reflex motor expression of some peripheral irritation of sensitive nerves. Such motor manifestations as a reflex result of peripheral irritation are not unfamiliar, even in adult life; as an instance we have the hysterical, and even epileptic, manifestations in females as a result of uterine disease. In infants the inhibitory action of the brain over the spinal cord is still in abeyance, and reflex action is more uncontrolled; there is an exalted irritability of the spinal cord, and hence these little patients are excellent subjects for the full manifestation of the evil effects of a constant peripheral irritant. Among the most constant of these peripheral irritants during infant life is dentition, and this is accordingly the most frequent cause of reflex eclampsia. There are those who believe that dentition, being a physiological process, cannot be connected with the production of so serious a pathological condition as convulsions, but they are of right in the minority. When it shall have been proved that other physiological processes are never productive of serious morbid states, then we shall give some credence to such a view; for the present, it is emphatically the opinion of the vast majority of authorities that difficult dentition is frequently the only assignable cause for a series of eclamptic attacks. The convulsion is often followed in a short time by the appearance of one or two teeth; some children have a convulsion preceding the breaking through of almost every tooth. We deprecate the assigning of dentition as a cause for almost all the diseases to which infant life is liable; but, on the other hand, we place this physiological process as the chief among the peripheral excitants which sometimes result in reflex eclampsia in infants. To account for the occurrence of these convulsions during the period of first dentition, and their almost uniform absence during that of the second, it is only necessary to remember that the condition of exalted irritability of the nervous centers, which is present in infants, is not present in the older children; hence a similar, or even greater irritation will fail to produce a convulsion in the older child, which in the infant might have produced a serious eclampsia. The gastroenteritis, which is one of the direct results and a concomitant condition of difficult dentition, may cause an attack of eclampsia in teething infants. In this case we would consider the eclamptic attack the result of the toxemia caused by the autointoxication from the stomach and intestinal tract, and not due to an irritation of the peripheral nerves terminating in the gums. For an excellent discussion of the subject of dentition eclampsia I would refer the reader to Fleischmann[9] and Politzer.[10]

Helminthiasis is another condition which is supposed by many authorities to give rise in some cases to eclampsia infantum. Such convulsions occur more frequently with the larger worms (round worms, tenia). I recall a severe epileptiform attack in an adult, who had never suffered from epilepsy, which preceded the expulsion of a tapeworm. Other authorities give undoubted cases in which the convulsions were the precursors of the discharge of large quantities of worms. It must not be forgotten, however, that the convulsions may depend upon the intestinal catarrh which is the result of the helminthiasis. Here, again, the toxemia resulting from the autoinfection from the bowels is the cause of the convulsions. The autointoxication may also be caused by the absorption of toxic products specific to the parasite or such as arise from undigested food due to the

catarrhal enteritis produced by the presence of the parasite.

The irritation of indigestible food, or food in too large quantities, may be the cause of a convulsion. In these cases, again, the convulsions may be reflex in character as a result of the irritation of the indigestible matter in the stomach, or they may be produced by an acute rise of temperature; finally, the spasm may be the result of a toxemic condition of the blood. If the attack be the result of the irritation of indigestible food, it generally occurs soon after the ingestion of the offending nutriment. Children vomit so readily that emesis will generally free the stomach from this irritant, and thus prevent a repetition of the attack. This cause of eclampsia has been acknowledged and well recognized as far back as the time of Hippocrates.

I am disposed to class under this head the occasional attacks of eclampsia resulting from preputial irritation and masturbation[11] in children. Where these attacks are frequently repeated, however, they would with more propriety be classed as epileptic. Other peripheral irritants have been observed, by good authorities, to produce convulsions in children. Soltmann mentions a case in which ascent of the testicles into the inguinal canal resulted in a convulsion. Foreign bodies in the ears have been repeatedly shown to be active in the production of a convulsion. Scalding of the surface of even a small portion of the body, or any other extremely painful, sudden injury, even if of short duration and of slight character, has been sufficient to produce an eclamptic attack.

*Toxic Eclampsia.*—The group of toxic eclampsia, although least understood, is by far the most interesting. In this class I include all eclamptic attacks which seem to depend upon some blood change which renders it unfit to nourish the nerve centers. We do not know enough of the changes produced by different diseases in the composition and constitution of the blood to enable us to state, with even an approach to positiveness, the exact alteration upon which this toxic action of the blood depends. In some cases it may be that there is a change in the quantity or quality of the constituents of normal blood; in others foreign substances (toxins) may have appeared in addition to the normal ingredients. We cannot here enter upon a discussion of the various kinds of toxemia and bacteriemia which cause the septicemia in the different diseases, but the fact is undisputed that the blood in such conditions acts as an irritant to the nerve centers, and this irritation manifests itself in eclamptic seizures. One fact seems to be characteristic of this form of eclampsia, and that is, that the attacks do not occur at the outset, but generally in the course of a disease. To this group belong the convulsions which occur in the course of a pneumonia as a result of the insufficient aëration of the blood[12]; and here also belong the convulsions (Stickungskrampf) accompanying the dyspnea of severe croupous and diphtheritic laryngitis, and those accompanying the dyspnea of prolonged attacks of laryngismus stridulus and whooping-cough. As will be seen later on, in every complete epileptiform attack the clonic convulsions are the result of the strangulation produced by the early tonic spasm of the respiratory muscles, and it is therefore not surprising that similar clonic convulsions occur in diseases whose chief clinical manifestation is spasm of the respiratory muscles.[13] An important class of cases belonging to this group is the eclampsia of scarlet fever, which is the result of a concomitant kidney affection with albuminuria. The retention of the urea in the blood is the cause of the convulsion. The occurrence of eclamptic attacks in primary or secondary parenchymatous nephritis is a frequent symptom in these conditions of the kidney. The convulsions occurring in the course of acute diseases which are non-febrile, but which seem to be dependent upon the action of the poison of the disease process, are well recognized, although we cannot define the nature of the toxemia in each individual case. We must not forget to mention, under this head, convulsions occurring as a result of permitting infants to nurse at the breast of a mother who has undergone some severe fright or mental shock. At the risk of being accused of belief in what is vague and unproven, I must express my conviction that nervous shock certainly does impair and alter the character of the milk secreted by the mother. The experience of ages teaches that a frightened mother should not nurse her child.

*Eclampsia of Rachitis.*—The eclamptic attacks which occur in rachitic children we place in a separate group, partly because eclamptic attacks are very frequent in rachitic children, owing probably to the especially exalted irritability of the nervous system, which is characteristic of rachitic children; but chiefly because one variety of eclampsia occurs in rachitic children exclusively; this is the condition known as laryngismus stridulus or laryngeal eclampsia.

Eclampsia as a Manifestation of Spasmophilia.—Among the idiopathic convulsions of infancy and early childhood, three types of convulsive seizures have been associated together as symptomatic of a general pathological condition more or less frequent, known as spasmophilia. These three types of convulsive manifestations are, attacks of spasm of the glottis, eclampsia, and tetany. It is not the purpose of this article to describe in extenso spasm of the glottis and tetany. However, a proper understanding of eclamptic attacks as they occur in spasmophilia necessitates some consideration of the whole subject of spasmophilia. The spasmophilic diathesis is a pathological condition, characterized by excessive hyperexcitability of the peripheral nervous system as shown by hypersensitiveness of the peripheral nerves and muscles supplied by them to mechanical and galvanic irritation. As a result there is a tendency in this condition to convulsive seizures, tonic and clonic, local or general. This condition is furthermore characterized by certain symptoms due to the electric and mechanical hyperexcitability. These are Erb's phenomenon, the Trousseau symptom, and the Chvostek symptom. These three symptoms are present to a greater or lesser extent in children suffering from spasmophilia even when no convulsions have ever occurred, nor spasm of the glottis or tetany. They are characteristic of spasmophilia even if the patient has never had any of the three types of convulsions, and are present in the intervals between attacks where these have occurred. They are characteristic of spasmophilia as a condition, irrespective of any essential urgent manifestation of that disease.

Although, theoretically, all cases of eclampsia ought to fall under one or more of the five groups into which I have divided the subject, yet clinically there may be cases which will not seem to depend upon any one of the assigned causes, and will have to be classified as a separate and distinct group, termed idiopathic eclampsia—in other words, cases that cannot be classified etiologically. This group will probably diminish with knowledge and improved methods of examination.

Etiology.—It has already been stated that infants have a marked predisposition to the occurrence of attacks of eclampsia. Why this should be so has occupied the attention of many excellent observers, among whom may be mentioned Nothnagel and Soltmann, the latter of whom has written a monograph on the peculiarities of function in the brain and spinal cord of infants. Clinically, we recognize that children under two years of age are more frequently seized with eclampsia than children beyond that age. So frequent is this disease in infancy that it may be counted as the most fatal pathological condition to which infancy is liable. By this is not meant that the prognosis of all attacks of eclampsia is necessarily bad. On the contrary, the prognosis is very good, but so

frequent is the condition itself that notwithstanding its comparatively favorable prognosis it still causes the death of more infants than does any other affection. The fact that it occurs most frequently during the period of dentition led many of the older writers to ascribe eclampsia to the dentition process; but the exalted reflex irritability of the spinal cord in infants, as already set forth, is the only element necessary to account for the predisposition to convulsions shown at this time of life. Heredity is an additional factor which helps to augment this natural predisposition. Most physicians in active practice will recall families in which all of the children have "spasms," while in other households such a thing is entirely unknown. A careful examination will generally reveal the fact that in the former class of patients the parents are of a nervous temperament; there may be a history of insanity, paralysis, or convulsions in other members of the family; in other words, these patients give a neurotic family history. It does not appear that either sex shows any predisposition for the disease. Male and female children seem to be equally liable to convulsions; if individual experience is of any value in this connection, I think I have observed more children with convulsions among the male sex than among females. As to the exciting causes, they have been thoroughly discussed in a previous paragraph.

Rickets is a frequent cause of eclampsia, owing to a variety of pathological conditions which, while they are the direct results of the rachitic changes in the tissues and fluids of the body, affect the brain and spinal cord more especially. Such convulsions, when the result of a gross lesion of the brain and spinal cord, are not to be classed as true eclampsia for the purpose of this article. Frequently eclamptic attacks in rachitic children are the result of a febrile, reflex, or toxic condition, insufficient in degree to have produced convulsions in healthy children, yet sufficient to disturb the balance of the delicately poised nervous system of these rachitic patients; so that the presence of rachitis is a predisposing factor in the causation of convulsions.

In addition to this, as we shall see when discussing the pathology of eclampsia, laryngismus stridulus is a form of eclampsia affecting rachitic children exclusively. It is the result in most cases of an autointoxication caused by the absorption of toxic materials produced in the stomach and bowels of rachitic children. This toxemia thus produced, acting upon the extremely irritable nervous centers of rachitic children, initiates a central irritation passing to the motor nerves of the larynx.

It would, however, appear that such a selective action of the toxic products of the blood upon the central origin of the laryngeal motor nerves must necessarily be initiated and aided by an irritation passing from the respiratory tract, of which the glottis is the entrance, to nerve centers. Such an irritation is found, first, in the catarrhal conditions affecting the respiratory tract of rachitic children; second, in the malformations of the thorax characteristic of rickets; third, in the inflamed, enlarged, and frequently suppurating bronchial glands, which by pressure upon the motor and sensory nerves of the larynx, initiate or aid an irritation which finds its peripheral expression in an attack of laryngospasm.

In cases in which the spasmophilic diathesis is present as shown by the recognized symptoms of such a diathesis this forms an important etiological factor. Causes insufficient to produce an eclamptic attack ordinarily will initiate one in such children. Latent spasmophilia affecting children who have never had a convulsion, or may never have one, is more frequent than active spasmophilia. When an eclamptic attack occurs that cannot be ascribed clinically to one of the other groups under which I shall consider eclampsia infantum, a very strong suspicion should be entertained that the spasmophilic diathesis is at the root of it, and the presence of the symptoms of such diathesis in such a patient increases the suspicion to almost a certainty. Indeed the spasmophilic diathesis may play a part in cases of eclampsia obviously due to some of the other factors which I have described, but in which these factors might not have initiated an attack of eclampsia in children not suffering from the spasmophilic dyscrasia.

Symptomatology.—A typical attack of eclampsia may be divided into two stages: First, the prodromal stage; second, the convulsive stage.

It is necessary to state that in many cases the first stage is entirely absent, and the second is so brief as to be scarcely noticeable. Many authorities have considered that the symptoms described under the head of premonitory symptoms are simply the marks of the general disturbance, of which the eclampsia is the result. Thus restlessness, a premonitory symptom to which all writers draw attention, may simply be a sign that there is something wrong with the little patient, without really foreshadowing a convulsion. There can be no doubt, however, that many children who are about to have a convulsion show this by a certain aggregation of phenomena which, to the anxious mother who has already experienced a convulsion in her infant, are the mutterings preceding the coming storm. In one variety of cases the child, which has been in good health, is observed to be feverish. There is a flush in the face, or the countenance may be exceedingly pale. The sleep is restless, the child starts, it grinds its teeth. As it lies dozing it may smile occasionally, or there may be a convulsive twitching of the lips and muscles of the face. The eyes are half closed, the nostrils move irregularly. It throws its arms and legs about, occasionally it sighs deeply, the breathing is irregular, although not stertorous; now and then the whole body starts violently, sometimes waking the patient and causing it to cry fretfully, to be followed again by drowsiness. These cases may be termed the somnolent cases. There are others in which the picture is an entirely different one. The little one is abnormally wakeful, it appears to be more than usually bright, the cheeks are flushed as though with hectic; the eyes sparkle, the pupils are enlarged; the muscles of different portions of the body twitch—now a finger, or arm, or leg, sometimes the eyelids, again the face—the child laughs more than usual, will not rest in the lap of its nurse, seems to prefer activity to rest, and asks to be taken from one attendant to another. The abnormal brightness and restlessness increase, until suddenly the little patient is thrown into violent convulsions. In these cases the parents will relate how bright the child had been before its spasm. There are other symptoms which may well be termed premonitory, although not so frequently observed as the two varieties just described. Thus I recall a little one who, in four out of six attacks of eclampsia (dentition), vomited a few minutes previous to its attack. There are other children who have many of the above-described symptoms without having an attack of eclampsia. In these cases the absence of the complete convulsion is due to a more than usually well-balanced nervous system, which, while yielding to the irritant to a certain extent, does not lose control of the "organ of mind" to a sufficient extent to place the body under the influence of the purely reflex nervous centers. Many cases have a convulsion without any of the above-described premonitory symptoms, or rather without any having been observed. There may not even be a cry, but suddenly the child falls into a more or less general and violent epileptiform spasm. The convulsive stage follows the prodromal symptoms after a shorter or longer period. But the prodromal stage, as has already been stated, may be entirely absent, or so little marked as to escape notice; then the convulsion proper sets in suddenly, often runs a rapid course, and the child recovers without sequelæ,

so that before the physician has arrived the child appears bright, and as though nothing had happened. This convulsive stage of eclampsia exactly resembles the convulsive stage of epilepsy. Indeed, most writers have agreed that the attack as such is indistinguishable from an epileptic seizure (Reynolds, Hughlings Jackson, Niemeyer, Brown-Séquard). While this is true for a typical attack of eclampsia, as compared with a typical attack of epilepsy, we shall call attention to several points peculiar to some attacks of eclampsia when we come to consider the subject of differential diagnosis. The little patient, who may or may not have presented the premonitory symptoms above described, is suddenly heard to cry out; the cry is immediately followed by a tonic spasm of the voluntary muscles; the body is thrown into the position of opisthotonos, the head is drawn back, the veins of the neck stand out prominently; the arms are rigid, abducted, and partially pronated; the hands are tightly clinched; there is a gurgling sound heard from the throat, as though the patient were choking; the teeth are firmly closed, the face is at first pale, but gradually grows congested and dark; the pupils are dilated, the eyes being open. This tonic spasm affects muscles of respiration as well as the voluntary muscles, and it is owing to this fact (Schroeder van der Kolk) and the interference with the venous return from the brain that the other clonic stage of the convulsion is due—that is to say, the clonic spasm is the asphyxial convulsion.

Fortunately the severe tonic spasm is but a few seconds or a minute in duration; were this not so, death from asphyxia during the tonic spasm would be more frequent. Even as it is, death sometimes occurs at this stage of the spasm. In the largest number of cases the brief tonic spasm is followed by clonic general convulsions. The extremities are alternately flexed and extended, the arms are pronated, the body is often shaken, and sometimes even raised from the bed in the violence of the convulsion. The eyeballs roll, and the head is turned to one or the other side convulsively. The lower jaw is moved forward and downward, and laterally; the tongue is sometimes caught between the teeth and bitten; there are swallowing movements performed by the larynx and pharynx; even the diaphragm may take part in these clonic convulsions, giving rise to hiccough which Soltmann considers a very dangerous symptom. Consciousness is entirely abolished; the conjunctivæ can be touched without the patient wincing. During this stage the sphincters may become relaxed, so that there is involuntary passage of feces and urine. The respiration is stertorous, the pulse frequent and intermittent. The temperature is elevated during the convulsion, even when the spasm is of non-febrile origin; in that case, however, it subsides very rapidly which is not the case in febrile eclampsia. The clonic convulsions may last from a minute to half an hour. In this respect attacks of eclampsia differ from those of epilepsy, which, as a rule, are not of long duration. The convulsions gradually diminish in severity until they cease, although convulsive movements may still remain localized in some muscles of the face or upper extremities long after they have ceased in other portions of the body. The patients return to consciousness gradually; they are at first irritable, soon they become drowsy, and frequently fall asleep. Such is a general description of an ordinary eclamptic seizure. This single attack is followed in many cases by a repetition, either shortly after the first convulsion or at a longer interval depending upon the etiology. If the convulsion is of the febrile variety, the reduction of temperature will generally cause a cessation of the spasm; should it belong, on the other hand, to the toxic or reflex group of convulsions, the frequency will depend upon our success in combating the etiological factor. When the patient falls from one convulsion into another, giving rise to a series of convulsions, he may be said to be in a condition analogous to the status epilepticus. Such a status may continue for days. Eclampsia, as well as epilepsy, may be very slight, consisting chiefly of a brief period of rigidity followed by little or no clonic spasm. There may even be nothing but slight paleness, accompanied by momentary loss of consciousness, and almost immediate recovery. These slight attacks, however, are not so frequent in eclampsia as in epilepsy (petit mal). Localized spasm, well defined in character and unaccompanied by loss of consciousness, cannot be regarded as eclamptic; thus a spasm of one arm or one leg, or of one side of the face alone, even with loss of consciousness, especially if repeated, would point to a local cerebral disease, and therefore cannot be classed in the group of eclampsia, but belongs rather to the class of localized epilepsies.

*Laryngismus Stridulus; Spasm of the Glottis.*—This type of convulsive seizure is in reality a manifestation of the spasmophilic diathesis and is not a true eclampsia. As I have stated, it is one of the three types of manifestations characteristic of spasmophilia. An attack of spasm of the glottis frequently terminates in loss of consciousness; there is therefore additional propriety in describing this manifestation of spasmophilia here, although a closer consideration of it is reserved for the article on *Spasmophilia* in a later volume. The condition, while eclamptic in character, is peculiar when considered as a convulsion. Cases differ from each other in severity to a very marked extent. In mild cases, the attack, occurring in children affected by active rachitis, consists of the sudden onset of a peculiar crowing respiration, repeated several times. The child turns pale, a look of dread overspreads the countenance, the loud crowing respiration becomes very rapid, the expiratory efforts being very short, the inspiration loud, crowing, and whooping in character. There is generally, however, no cough after inspiration as in whooping-cough—the face becomes cyanotic, consciousness is not totally lost. The patient very suddenly regains his normal condition. Such an attack may last from a few seconds to a minute or two.

A second class of cases are of a severe character. There are sudden paleness and total stoppage of respiration, followed by phenomena similar to those described in the milder attacks. In a third group of cases the spasm of the glottis, initiated as in the first and second classes, is so severe and long in duration that the patient is temporarily asphyxiated. The face and body are cyanotic; the pupils, at first contracted, become dilated; opisthotonos, with some spasms of the whole body and extremities, is in turn followed by clonic spasm and the other phenomena of an attack of a more or less general eclampsia. Such attacks of laryngismus stridulus, however frequent they may be, generally diminish both in severity and in number, as the rachitic disease is diminished and cured. Even in the worst attacks the eclamptic attack is generally followed by the sleep of exhaustion and the patient wakes up in a normal condition. Death from asphyxia very rarely occurs. This, however, does occasionally happen and sometimes in cases in which the attacks have been very mild. The frequency of the attacks varies, some patients having very few, one every four or five days, others one a day or night, while some have as many as forty or fifty attacks of greater or lesser severity in the course of a day. The severity of the laryngospasm varies with the severity of the autointoxication in the particular case. The attacks are generally initiated by some irritation or excitement, by overloading of the stomach or bowels with food, by draughts, by cold water, by fright, indeed by any external irritation.

*Symptoms of Spasmophilia.*—These are chiefly a demonstration of the mechanical and electrical hyperexcitability of the peripheral nerves, best demonstrated by the presence of the phenomena of Trousseau and

Chvostek, as marks of mechanical hyperexcitability, and the Erb phenomenon, a demonstration of the electrical hyperexcitability. The Trousseau symptom when present is shown by the production of tetany of the hand and forearm, on circular compression of the upper arm by the hand of the examiner or an elastic band in such a manner that the nerves to the inner side of the biceps are compressed. The Chvostek symptom is obtained by lightly percussing the cheek of the patient with the percussion hammer or the finger, at a point under the zygoma and midway between the angle of the mouth and the external auditory meatus. When the symptom is present, there results a rapid clonic contraction of the muscles supplied by the facial nerve on that side. A slight stroke instead of a blow will sometimes serve to elicit the phenomena. Erb's symptom is best obtained by placing the interrupting electrode of a galvanic current over the median nerve at the bend of the elbow, and the other electrode at an indifferent point. When the symptom is present, it will be found that contractions occur with much weaker currents than in normal children, that AnOC is greater than AnCC, and especially that CaOC occurs with currents weaker than five milliamperes. When typical attacks of infantile eclampsia occur that cannot be ascribed to any other of the causes I have enumerated above, especially if non-febrile, they are probably a manifestation of the spasmophilic diathesis, which can be confirmed by tests for the presence of these three symptoms.

Sequelæ.—Although in the large majority of eclamptic attacks, of which the patients do not die, recovery is complete, leaving absolutely no sequelæ, the text-books relate a large number of possible injurious effects from eclampsia infantum. A fatal result is far more frequent in these seizures than is generally supposed. Dr. West, in his work on "Diseases of Children," showed that in London the proportion of deaths from convulsions in children under one year, as compared with deaths from other causes, was twenty-one and nine-tenths per cent.; from one to three years, about four per cent.; and from three to five years, about three per cent. Other authorities also agree that eclampsia is the most fatal condition to which children under one year are subject. It is almost impossible, however, to estimate what proportion of infants thus attacked die, since only fatal cases are reported in official statistics, while private statistics are neither sufficiently numerous nor sufficiently trustworthy to be reliable. Of children who recover, many are subject to repeated attacks, even under slight or no provocation, and it becomes a question as to whether the eclampsia so called has not turned into chronic epilepsy. Among the authorities who favor the view that chronic epilepsy is often the result of repeated attacks of eclampsia are R. Demme[15] and E. C. Seguin.[16] It does not seem at all improbable that a frequently repeated convulsion may so disturb the equilibrium of the nervous centers as to render these liable to initiate a convulsion, even under slight provocation, finally terminating in confirmed epilepsy. It is more probable, however, that the cases in which a so-called tendency to eclampsia finally terminates in epilepsy are really at the start epileptic. Some conditions frequently known to give rise to eclampsia may have been present at the time of the first attack, and a diagnosis of eclampsia may have been hastily made; such cases will be cleared up, later on, by the more or less frequent recurrence of the attacks without any cause.

Some of the more immediate sequelæ of an eclamptic seizure are ecchymoses under the skin and conjunctiva. These hemorrhages appear to be the result of the venous congestion which accompanied the tonic spasm at the onset. The violence of the clonic spasm may be so great as to tear muscular fibers or tendons, or even produce dislocations. Indeed, a case has been reported in which a fracture of the sternum was caused by the violent contractions of the rectus abdominis. Temporary paralysis of individual muscles or muscle groups often results from an attack of eclampsia; this seems to be only functional, however, for in a few hours or days power returns and no trace of the paralysis is left. Temporary contractures may remain in the muscles that have been the seat of the greatest convulsions; thus wry-neck and various contractures have been observed to follow an attack of eclampsia. I recall a case in which the fingers of both hands remained contracted into the palm of the hand for two days after an eclamptic convulsion; but in a short time the patient recovered full use of his hands. I cannot agree, however, with those who claim that a simple attack of eclampsia, not connected with any lesion of the nervous centers, is capable of producing permanent paralysis or contracture. When a monoplegia or hemiplegia seems to result from an attack of eclampsia, I feel convinced that a careful clinical examination will point to the suspicion that the convulsion was the result of a lesion of the nerve centers resulting in convulsions, rather than that the eclampsia had resulted in the paralysis. It is claimed by those who hold the latter view that these paralyses are the result of meningeal hemorrhages over the motor area of the cortex of the brain as a result of the convulsion. It is possible that a monoplegia could occur in this manner, for even a very slight hemorrhage would be sufficient to affect the functions of a limited area of the cortex. A hemiplegia, however, produced in this manner would necessitate the presence of a clot sufficiently large to interfere with the whole of the motor area of one hemisphere; that such a hemorrhage should occur as a result of an attack of eclampsia is scarcely conceivable. Some common congenital deformities, such as club-foot, for instance, have been ascribed to attacks of eclampsia occurring in fetal life, and resulting in contractures of the muscles. A careful study of these deformities will generally reveal their true etiology.[17] I am disposed to consider all cases of permanent paralysis or contracture (primary or secondary) in children the result of a lesion of the nervous centers, of which the convulsion was only a symptom; in such cases there will generally be found some more rational method of accounting for the production of the paralysis than that which refers it to meningeal hemorrhage as a result of eclampsia.

Diagnosis.—Eclampsia may be confounded with epilepsy, and with convulsions due to disease of the nervous centers. From epilepsy it can be distinguished by a careful examination into the previous history. The older the child, the more often the convulsions have occurred without any recognizable cause, the more probable becomes the diagnosis of epilepsy. In this connection it must not be forgotten that attacks that were originally eclamptic may, after a time, when the convulsive habit has been acquired, become epileptic. Such children must be carefully watched, and should any suspicion of the presence of chronic epilepsy arise, the patient must be treated accordingly.

As far as the attack of eclampsia itself is concerned, there is no way of distinguishing it from an ordinary attack of epilepsy. Convulsions due to disease of the nervous centers have certain peculiarities which distinguish them from ordinary attacks of eclampsia. One important characteristic is that these convulsions are apt to be localized, especially if due to chronic brain disease; lesions of the various motor centers will give rise to convulsions limited to portions of the body supplied with nerve force from these centers. In acute diseases of the brain and spinal cord, and their meninges, there will be other symptoms which will lead to a diagnosis of the disease, of which the convulsion is only one of several manifestations. A differen-

tial diagnosis of the different varieties of eclampsia infantum will depend upon a careful physical examination of the patient. If there is fever or toxemia, it should be recognized together with the disease which has produced it. If the convulsion appears to be due to neither of these causes, we should carefully search for some possible peripheral irritant, and, if possible, remove it. Accuracy of diagnosis is apt to depend in these cases upon the broadness of our knowledge of diseases and conditions of infancy. To attempt to treat a case of eclampsia infantum without at least an attempt at an etiological diagnosis, is to submit the patient to the most injurious form of empiricism. The convulsion is a symptom of a disease which the physician must detect. We must search for the pneumonia, the diphtheria, the scarlet fever, the cause, and treat that at the same time that we treat the symptom. From tetany, eclamptic attacks can be distinguished first by the absence of loss of consciousness in tetany and the presence in the latter condition of drowsiness. The presence of Trousseau's symptom will also serve to distinguish the cases of tetany. This consists in the observation by the clinician that in tetany an attack of spasm can be produced by compressing with the fingers the point of emergence of motor nerves from bony canals. The differential diagnosis from hysteria is hardly a factor in young children. Laryngismus stridulus can be differentiated from whooping-cough by the character of the attack and the absence of the short, broken, and rapid cough which follows the long-drawn inspiration of whooping-cough.

Pathology.—Eclampsia infantum, being rather a symptom than a disease, has no pathology. It is true that morbid changes have been found in the nerve centers of children who have died of an attack of so-called eclampsia, but the mere fact that these changes were found precludes the diagnosis of eclampsia, which is essentially a convulsion that does not result from any grave lesion of the nervous centers. It is possible that repeated attacks of eclampsia result in subtle changes in the nerve centers, but if this be the case the changes are not discoverable by any method of examination practised in the present stage of pathological investigation.

Concerning the pathological mechanism by which an attack of eclampsia is produced, it will be proper to say a few words. The subject belongs of right under the head of epilepsy, as it is in connection with epileptic convulsions that it has been more thoroughly studied. Clinically, we have already stated, the eclamptic paroxysm in no way differs from an epileptic attack. The mechanism by which the latter is produced is stated by Reynolds,[18] in his "System of Medicine," as follows:

"The derangement consists in an increased and perverted readiness of action of these organs (medulla and vasomotor system of nerves), the result of such action being the induction of spasm in the contractile fibers of the vessels supplying the brain, and in those of the muscles of the face, pharynx, larynx, respiratory apparatus, and limbs generally. By contraction of the vessels the brain is deprived of blood and consciousness is arrested; the face is or may be deprived of blood, and there is pallor; by contraction of the muscles which have been mentioned there is arrest of respiration, the chest walls are fixed, and the other phenomena of the first stage of the attack are brought about.

"The arrest of breathing leads to the special convulsions of asphyxia, and the amount of these is in direct proportion to the perfection and continuance of the asphyxia.

"The subsequent phenomena are those of poisoned blood, *i.e.* of blood poisoned by the retention of carbonic acid, and altered by the absence of a due amount of oxygen."

These are practically the views held by Kussmaul and Schroeder van der Kolk,[3] as to the manner in which a paroxysm is produced; the causes of the primary derangement of the nervous centers will vary with the cause of the convulsions: in one case it is elevated temperature, in another toxemia, in a third a peripheral nervous irritation, and finally the changes and phenomena due to rachitis.

As I have already stated, only such cases of rachitic eclampsia as are due to a toxemia depending upon autointoxication and the special cases, already considered, of laryngeal spasm, are properly eclampsias. Convulsions due to gross lesions of the brain and of the cranial bones cannot be regarded as eclampsias but rather as symptomatic epilepsies. Thus, for instance, the condition of the skull, known as craniotabes, so frequent in rickets of very young children, renders the brain very much subject to external pressure owing to the pliability of the cranial bones. Convulsions due to such pressure over the motor cortex of the brain are localized epilepsies due to craniotabes. Convulsions of a general character due to hydrocephalus, which is one of the results of rickets, would also be excluded from functional eclampsias, being due to an organic brain lesion. Osteophytic hypertrophies of the inner tables of the skull, causing localized pressure over the brain structure, especially over the motor areas of the cortex, might produce convulsions which would be of the Jacksonian type and not eclampsias, such as we here consider. The general convulsions, however, due to the blood changes resulting from the autointoxication of rickets, as well as such as result from the chlorotic condition of the blood (lower percentage of hemoglobin, diminished red blood globules) found in rickets, and those due to febrile, reflex, or toxic causes, slight in character and yet producing convulsions owing to the more than usually excited irritability of the nervous centers in rachitic children, such convulsions are of right classed as rachitic eclampsia.

As to why convulsions occur in febrile eclampsia is best understood by discussing some important points in the pathology of fever. Fever itself is a nervous phenomenon, the effect of a primary derangement of the nervous system. Normal temperature is dependent upon the maintenance of a proper proportion between heat loss and heat production. The mechanism which controls this proportion resides in the central nervous system. In fever this mechanism is disturbed. Observers have sought to localize the portion of the nervous system in which this mechanism resides. There is a large literature upon this subject, and although much work must yet be done before we shall know as much of the localization of heat centers as we do of motor-nerve centers, or of the origin, course, and distribution of thermic nerve tracts as we do of motor tracts, yet this much has certainly been established that the heat function of the body is under the control of large nervous centers chiefly located in the brain and probably distinct from the motor centers. The thermic nerve tracts, although separate in the brain from the motor-nerve tracts, are closely connected with the latter at the medulla oblongata.

It would appear, then, that an attack of eclampsia, occurring in the course or at the outset of a disease of such a character that the accompanying elevated temperature is apparently the causative element, so far as the convulsion is concerned, calls into activity two sets of nerve centers—the thermogenic center or centers, and the convulsive center or centers.

Hughlings Jackson has shown that what he calls a "discharging lesion" of any portion of the brain may initiate the action of the medulla as a convulsive center. We do not know the nature of such a "discharging lesion"; it leaves no trace which can be demonstrated at the postmortem table. It may be excessive hyperemia, or anemia, or some minute

change in structure. We have no means at present of demonstrating the lesion. A similar alteration or lesion occurs in the thermogenic center. Its effect is fever or rise of temperature; secondarily, it throws into activity the unstable convulsive center, if I may so term it, in the medulla, especially in infants, in whom, as has been seen, the medulla, together with the motor centers, is in an exalted state of irritation. Furthermore, it is probable that, in the medulla, the motor and thermic nerves are intermingled. What more natural than that an irritation of the one results in an irritation of the other? Of the probable correctness of this hypothesis we have, however, another proof. The same reasons that would lead us to expect that the irritation of the fever centers should, in proper subjects, cause an irritation of the convulsive center would also presuppose the possibility of a reversal of this process. In other words, we should expect the activity of the convulsive center to produce a secondary activity of the fever center. This is certainly fully demonstrated by practical experience at the bedside. All authorities are agreed as to the enormous rise of temperature which occurs in the course of a so-called "status epilepticus." The epileptic falls into convulsions, repeated at very short intervals, so that the patient does not recover consciousness for hours, or even days. Shortly after this condition has set in the temperature begins to rise, and sometimes reaches an enormous height. Bourneville has seen it as high as 107.5° F.; Reynolds reports equally high temperatures.[19]

Pathogenesis of spasmophilia, so far as eclampsia infantum is concerned, is of interest only in so far that it is important to remember that the characteristic symptoms of spasmophilia depend for their occurrence upon the condition of the mechanical and electrical hyperirritability of the peripheral nerves and medulla. As to the influence of disease, removal or absence of the parathyroid bodies in the pathogenesis of spasmophilia in children and tetany in adults much must be said under the appropriate article (spasmophilia). Eclamptic attacks, however, due to such gross anatomical lesions would, from that alone, be excluded in the consideration of functional eclampsias. Spasmophilic eclampsia has also been ascribed to congenital syphilis in the affected child. Where, however, the lesion is a gross specific congenital lesion of the nerve centers, the attacks again cannot be considered as functional eclampsias. Spasmophilic eclampsia may be due to the general constitutional effects of congenital syphilis and such a pathogenesis should be considered in appropriate cases.

Prognosis.—The prognosis of an attack of eclampsia resolves itself into two elements: first, as to the fatal or non-fatal termination of any attack, and secondly, as to the recurrence of the convulsion. Although many infants die in an attack of eclampsia, yet, when we consider the great frequency of such attacks, those that die are comparatively few in number. The prognosis in this respect does not depend upon the severity of the seizure; very severe convulsions will often last but a short time and terminate in complete recovery. The duration of an attack of eclampsia is a more important factor in the prognosis. A series of convulsions of long duration, with short intervals between the individual attacks, renders the prognosis grave; and yet children sometimes recover after lying in "status convulsivus" for one or two days. Convulsions in which one side appears to be far more affected than the other are much more apt to be fatal than those in which the difference between the two sides is not so marked. A fatal termination, as well as a repetition of attacks of eclampsia, will often depend upon our inability to remove the cause which lies at the root of the derangement of the nervous centers. An attack of eclampsia may be repeated either within a short time after the original attack, and is then probably due to the same cause as the original convulsion; or after the lapse of weeks and months, and must then be studied with reference to its etiology as an entirely new seizure. If after an eclamptic seizure a child recovers completely and returns to its normal condition, and especially if the cause of the convulsion has been surmised and removed, the prognosis is good, the convulsion will probably not recur; it is best, however, even in these cases, to be guarded and prepare the patient and friends for a recurrence, rather than the contrary. In the large majority of cases, however, and above all in those cases in which the cause of the convulsion cannot be removed or is unknown, the convulsion is apt to be repeated; the more frequently the convulsion is repeated during a limited period of time, the more unfavorable the prognosis as to recovery. The convulsions are more apt to be multiple in the peripheral and toxic variety of eclampsia than in the febrile. The reason of this is obvious, inasmuch as fever is a condition which, temporarily at least, may be removed, while the former two do not so readily admit of treatment. A child that has already had attacks of eclampsia is far more liable to repeated returns of convulsions, under the influence of proper exciting causes, than one that has never had a convulsion. In the former case the nervous system has already shown its instability, and hence our distrust. In conclusion I would repeat, the prognosis depends to a great extent upon our ability to recognize and treat the cause. In rachitic eclampsia, while the rachitic disease is on the increase, the liability to eclampsia is on the increase. When the rachitis is cured, the eclamptic attacks as a rule no longer recur.

Treatment.—In discussing the treatment of eclampsia infantum, we would repeat what has been urged concerning the necessity of a careful differential diagnosis as to the etiology of the convulsion. We should distinguish whether the convulsion belongs to the febrile, the toxic, or the peripheral group of convulsions. If it belongs to the former, the abnormally elevated temperature should be reduced as speedily as possible. For this purpose rapid and certain means should be employed. Cold sheets, sponging with equal parts of cold water and dilute alcohol, cold baths, Ziemssen's baths—all of these are excellent methods of reducing the temperature by external means, and our choice should be governed by general principles. Among antipyretic drugs, the best, most trustworthy, and most rapid antipyretic is antipyrin, in proper doses and at proper intervals. I am accustomed to give to children, a year old, gr. v. every hour until two doses have been taken, and to repeat the dose in six hours if the temperature shows a tendency to rise again. The object being to reduce temperature, the drug must be used in sufficient quantity to effect our purpose. If the convulsion be of the toxic variety, the indication is as far as possible to get rid of, or diminish, the toxemia of the blood; the kidneys, the bowels, and the skin, all the excretory channels, should be brought into play. An enema, together with a cathartic, should be administered; a mustard bath should be given to produce sweating and to make the skin act vicariously for the kidneys; should these organs be at fault diuretics should be administered if not contraindicated by the general disease. Should the convulsion depend upon a peripheral irritant, it must, if possible, be removed. If the stomach is overloaded, an emetic should be administered; if constipation appears to be the cause, the bowels must be emptied. If dentition is the cause, and the gums are swollen, lancing is indicated; the swelling will thus be diminished, the teeth will be more easily cut through, and the irritation removed; if helminthiasis is at the

root of the evil it must be treated. Whatever the peripheral irritant may be, it should be removed. There will be many cases that cannot be classified, which must be treated on general principles. In addition to treating the etiological element in any attack of eclampsia, it has been the custom of physicians to administer a class of drugs known as antispasmodics. The most important of these are the bromides and chloral hydrate, and during the convulsions amyl nitrite and chloroform. The bromides should be given in comparatively large doses to produce a beneficial effect. Thus, I am accustomed to give gr. vi. to gr. viij. every three hours to children one or two years old; even larger doses should be given if necessary until the convulsions cease and sleep is produced. Chloral hydrate may be used in small doses, either alone or in combination with the bromides. I have used amyl nitrite, a few drops inhaled from a handkerchief during the convulsions, with but little success; I have been unable to convince myself of its utility when thus presented to infants. Should the convulsions be very severe and continue for a long time, chloroforming the little patient may be tried, although in cases severe enough to require this measure the convulsions are apt to return as soon as the effect of the chloroform passes away. In cases in which the bromides must be administered during a convulsion, it is best either to inject the drug per rectum or subcutaneously in solution. When given by the rectum the dose should be at least twice as large. I have always considered the application of cold cloths or ice-bags to the scalp as superfluous in ordinary eclampsia; if they accomplish any good at all it is only in cases in which reduction of temperature is an element in the treatment, and in these cases we have more effective means for accomplishing this result.

For the attack Trousseau advised compression of the carotids, either one or both, until the convulsions subsided. The carotids are compressed opposite the thyroid cartilages, by pressing the artery against the spinal column. The corresponding side of the face thereupon becomes pale and then cyanotic. In most cases the convulsive movements gradually cease and the patient falls asleep. Should the convulsion not cease the compression must be stopped as soon as the cyanosis is extreme. The compression may be repeated at quarter- to half-hour intervals; should it then not succeed in checking the convulsions we should not advise its repetition. It must not be forgotten that, whatever may be the disease of which the convulsion is a symptom, our attention must be mainly directed to the treatment of it, and not to the treatment of the convulsion alone.

When convulsions occur simply as a manifestation of the spasmophilic dyscrasia, the treatment is directed to improving the general health. It is found that spasmophilia is less frequent among breast-fed children, so that here is another factor which emphasizes the importance of breast feeding of infants whenever it is possible. It is as important in the prevention of spasmophilia as in the prevention of rachitis. Discussion as to the proper modifications of the milk in artificial feeding of such children together with the cognate question as to the chemical content of the food, such as excess of lime salts, etc., will best be taken up under the heading "spasmophilia." I would refer, however, here to the importance of giving phosphorus in some form, preferably small doses of Thompson's solution, well diluted, to rachitic infants showing the spasmophilic symptom-complex. It follows naturally that in the treatment of spasmophilic eclampsia, where congenital syphilis appears to be a factor in the pathogenesis, the modern antispecific therapy is important from both a prophylactic and a curative standpoint.

HENRY W. BERG.

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**Eclampsia Nutans.**—*Synonyms:* Spasmus nutans or nodding spasm.

This is a peculiar affection found in young children, especially in the first two years of life, in which there are rather slow rhythmic movements of the head either of nodding or of rotation from side to side. With these are combined in the majority of cases a lateral nystagmus. These movements are usually initiated by the child's head being turned in some one direction, as in looking at an object to one side, and the idea has been brought forward that it is produced especially in children who are kept constantly in ill-lighted rooms by the necessity which they are under of having to turn the head and eyes into some strained position, in order to get proper light upon their toys or other objects. Upon further investigation, however, it appears that the affection is by no means confined to children who have been brought up in gloomy ill-ventilated rooms, though it is more frequent in those who have been exposed to the influence of unhygienic surroundings and régime. Koplik and others have found it commonly associated with rickets. In some cases it seems to be of the nature of a habit spasm.

It tends to spontaneous recovery as the child grows older, but its cure is favored by the treatment of rickets, when present, and by general tonic and hygienic measures. If the spasm is severe the bromides may be administered temporarily. If the child is old enough, reëducation of movements may be attempted. Any condition favoring reflex irritation should, if detected, be corrected as far as is possible.

CHARLES LEWIS ALLEN.

**Ecphyma Globulus.**—A name given to a contagious skin disease that manifested itself in Ireland during the famine years of 1847-48 and called by the Irish peasantry "button scurvy." Frazer, who described the disease, thought that it resembled

frambesia or yaws of the West Indies. It seems practically to have died out. The eruption, according to Frazer, occurred on any part of the body except the hands and feet, the lesions starting as slight elevations or tubercles. In this stage the skin over the lesions is perfectly normal. Increasing slowly in size the tubercles become discolored, gradually soften, finally forming prominent deep-red tumors looking like raspberries though considerably larger. These persist for an indefinite length of time unless treated, but the free use of nitrate of silver causes them soon to heal.

CHARLES TOWNSHEND DADE.

**Ecstasy.**—Ecstasy (ἔκστασις, displacement) is a peculiar condition of the nervous system, in which the motor and sensory functions are totally or partially in abeyance, while mentally the subject is in a state of intense abstraction, his consciousness being under the domination of hallucinations, or of a narrow group of ideas, usually of a religious character, so that he appears to be listening with rapt attention to sounds, or wholly occupied with visions, perceptible to him alone, his whole attitude being that of one who has been transported beyond the sphere of earthly things, and is contemplating with joy or with awe some celestial manifestation. There may be either muscular relaxation, or a certain rigidity, the action of the heart and respiration are temporarily reduced, and there may be partial or total anesthesia. Since the subject is as a rule wholly oblivious to his external surroundings, memory for what has actually occurred during the period of ecstasy is defective. He may, however, be able to narrate, in whole or in part, his experiences during the ecstatic state, and the tales told have played an important part in the religions of all ages. Ecstasy has close relationships with catalepsy, trance, hypnotism, and hysteria, though it is also observed in delirious conditions arising in connection with other psychic disturbances, notably in epilepsy. In the case of some religious enthusiasts, ecstasy is probably a result of autohypnosis, due to extreme absorption and the concentration of the mind upon the one object most intensely desired, namely, of attaining intimate communion with heavenly beings, aided perhaps by certain physical procedures, as in the case of the monks of Mount Athos and certain Hindu ascetics, who are said to aid themselves in passing, in thought, to Heaven by the strain of fixing their eyes with unbroken attention upon the umbilicus. It has been suggested that some of the martyrs may have been able to escape a large part of the physical pain of their final immolation, by passing into the anesthesia of the ecstatic state, through rapt concentration upon the thought of their approaching admission to the ranks of the Heavenly Host.

CHARLES LEWIS ALLEN.

**Ecthyma.**—This form of pustulosis of the skin is not, strictly speaking, a disease separate and distinct. It is rather a secondary or consecutive lesion occurring in many and varied disorders, in which the clinical type remains fully constant. A predilection is displayed in most cases for the extremities, the lower in particular, but the trunk and neck are often attacked.

In the beginning there is a small pustule which generally takes a rounded outline, although the character of the local injury may give it an unusual appearance; for example, linear in infected scratch marks. When fully developed, the pustule, tense or flaccid, is seated on an indurated base whose redness fades gradually into the surrounding skin. The purulent contents soon dry into a thick, dark crust, adherent, and showing on removal a superficial ulceration of the corium. The base of the ulcer is uneven, due to indolent granulation tissue and of a red or grayish color from the presence of pus. In syphilis, the crust of ecthyma becomes stratified (rupial) like the shells of crustacea, due to spreading of the lesion under its dried cover. The ulcer heals slowly and with the formation of a small scar, which is always evident when the patient is afterward stripped for examination. Development is rather slow, but the individual pustule usually runs its course in a fortnight. It may be single or be accompanied by others, developed either coincidentally or appearing in successive crops. Subjective symptoms are those of burning and pain; itching, if present, is due to previous disease.

*Ecthyma gangrænosum* may be separated from the mass of ecthyma and given a definite place on account of its etiology and its occurrence in young, cachectic children. The lesions are apt to appear on the buttocks, thighs, and perineum and are extremely indolent. The ulcers are of a deep red color and covered by a dirty, tenacious slough, varying in size up to that of a silver quarter of a dollar. The earliest lesion observed is a brown or dark-red discoloration, which becomes necrotic. In Kreibich's case there were twenty-five or thirty ulcers at one time.

ETIOLOGY.—As in other conditions, especially those of a purulent character, three factors determine an outbreak of ecthyma: first, a depraved state of health, second, a point of entrance of diminished resistance for (third) the invading organism. The disease attacks all ages and both sexes, but is more common in adult males. Lowered vitality may simply, as in vagabonds, result from insufficient nourishment, but it may be a part of infections like syphilis and tuberculosis (scrofuloderma of Duhring), or of diabetes, Bright's disease, and anemia. The injury to the tissues is most often due to scratching, commonly of louse, bedbug, and flea bites, but also in the course of the pruritus of eczema, diabetes, dermatitis herpetiformis, and senile pruritus. Localization of specific morbid products furnishes a portal of entry doubtless in the granulomata, syphilis, and tuberculosis. The invading organism is in most cases the streptococcus, inoculated by dirty finger nails, clothes, and bedclothes. The other pus cocci of course may be present. The *Bacillus pyocyaneus* seems to be responsible for ecthyma gangrænosum—I say seems, because it is quite possible that it is inoculated in ulcers perhaps due to another organism, from alvine discharges. At any rate, it has been regularly found by such men as Ehlers, Baginsky, and Kreibich. The infants are invariably cachectic.

HISTOPATHOLOGY.—The pathological process begins in the corium in the form of a circumscribed area of purulent inflammation. The cellular infiltration is chiefly of polynuclear leucocytes, the vessels are dilated and congested, and the tissue elements at the periphery are separated by a serous exudate. Later, a central necrosis occurs with complete solution of fibers, vessels, and skin appendages in its area. The epithelium covering the pus collection is much swollen, owing to an intracellular as well as an intercellular edema. Many of the cells show hydropic degeneration. By specific staining, a network of fibrin can be demonstrated at the center. The crust is composed of fibrin filaments in whose meshes are entangled epithelial cells and leucocytes; when it separates there is left an ulceration which extends into the cutis and which heals by the usual process of granulation and scar formation. Slight pigmentation may persist for a little time,

DIAGNOSIS.—Differentiation of ecthyma from other pyodermias is a matter of small importance as compared with recognition of the underlying condition. Impetigo contagiosa is superficial with a "stuck-on" crust which leaves on removal no ulceration; pustular eczema is a diffuse process with no epidermal destruc-

tion; furuncles show unmistakable necrotic plugs. The ecthyma of syphilis has an indurated base, its crust commonly takes on a rupial character, and the ulceration is apt to be characteristically reniform. In the absence of external factors, careful search for a causative systemic condition—such as anemia, cachexia, and, too often, starvation—must be made. When the skin shows excoriations and no pediculi or other parasites are to be found, it becomes necessary to decide which of the itching dermatoses is at fault—an eczema, an urticaria, a pruritus, or a dermatitis herpetiformis.

Prognosis.—The outlook is invariably good so far as ecthyma itself is concerned, but on recovery from the pyodermic condition the prognosis becomes that of the causative, underlying disease. Ecthyma gangrænosum is always a grave condition, merely, however, as a sign of deep systemic depression.

Treatment.—Soap and water, good food, and tonics constitute all that is really necessary. Even the pustular syphiloderm and scrofuloderm will get well with them alone, but the cure may, it is hardly necessary to remark, be hastened by appropriate local measures. In vagabonds' disease, the clothes and bedclothes should be boiled to kill lice and, if possible, the patient should be changed to a clean bed. After a preliminary bath, the crusts may be softened by sweet oil, boric-acid poultices, or ointment, and removed. The bases of the ulcers are cleaned with hydrogen peroxide and covered by antiseptic surgical dressings. Gauze soaked in fifty-per-cent. ichthyol in watery solution is admirable for the purpose since it never starts a dermatitis of its own. The solid stick of silver nitrate is used to restrain exuberant granulations. In dispensary practice where elaborate dressings are usually out of the question, ecthyma heals readily under inunction with ten-per-cent. sulphur ointment, but its use must be stopped before it excites a reaction in the skin. Treatment of underlying cachexias must be left for consideration in their proper places. James C. Johnston.

**Ectoderm.**—The ectoderm is the outermost layer of cells in the embryo, or outer germ layer. It is called ectoblast by some German, and epiblast by some English writers. The cells early arrange themselves so as to form a distinct epithelium; in the median line of the embryo the cells become thickened and give rise to the so-called medullary groove, out of which the nervous system is developed, these median cells becoming entirely separated from the rest of the ectoderm, which thus becomes the embryonic epidermis. The epidermal ectoderm develops all the epidermal structures of the adult, and also gives rise to the epithelium of the auditory labyrinth and to the lens of the eye, as described in the special embryological articles. Charles S. Minot.

**Ectropion.**—See *Eyelids, Affections of the.*

**Eczema.**—*Synonyms:* Ger., *Eczem;* Fr., *Eczéma;* Tetter, Salt rheum.

Definition.—Eczema is an acute or chronic inflammatory disease, presenting a most varied assortment of cutaneous lesions, and accompanied by more or less intense itching, burning, or pain. The lesions consist, at first, of erythema, papules, vesicles, or pustules, which may subsequently form into crusts or weeping surfaces, or infiltrated and scaly patches.

General Symptomatology.—All eczemas possess certain characteristics and are associated with definite general symptoms which may be briefly referred to before taking up the study of the disease in its various phases. Eczema is distinctly an inflammatory affection, and as such manifests, in some degree or modification, the cardinal symptoms of that process. These are: (1) congestion, with swelling and increase of local temperature; (2) fluid exudation into the tissues, with the formation of vesicles and pustules, or with a discharge upon the surface, resulting in crusts and scales; (3) plastic exudation, producing papules, patches of infiltration, and thickening; and (4) subjective sensations of itching, smarting, or burning pain.

The character and intensity of these various symptoms will depend upon the acuteness or chronicity of the inflammation, upon the locality affected or the extent of territory involved, upon the inherent temperament or peculiarities of the individual, and upon his habits of diet, the nature of his occupation, etc.

(1) *Erythema.*—The erythema may vary from the bright red blush which is seen in the acute forms of the disease to the dull redness commonly observed in the more chronic erythematous varieties. The amount of swelling accompanying it is a varying quantity, dependent generally upon the acuteness of the inflammation. An increase of local temperature is always appreciable, more marked in the acute than in the chronic forms, but is never a very decided symptom, such as that accompanying some other inflammatory affections, *e.g.* erysipelas.

(2) *Serous Exudation.*—Exudation is a part of every eczematous process, the form of lesion produced thereby being determined by the various influences already enumerated. Fluid exudate will produce swelling, vesicles, and pustules, and when rupture occurs there will be a weeping, moist surface which dries into crusts and scales. The crusts are often thrown off rapidly, leaving a more or less continuously weeping or moist patch, or areas of greater or less extent. This discharge has the peculiarity of stiffening linen with which it comes in contact.

(3) *Plastic Exudation.*—When the exudation is plastic, papules and dry scaly patches result, the scales being either fine and branny or they become agglutinated into larger flakes, which are sometimes quite thick. The former are usually seen in the erythematous type of the disease, commonly found upon the face, or in the dry scaly eczema of the scalp; while the latter are observed chiefly in connection with chronic squamous eczema. Infiltration is present in every form of the disease, but it is only in the more chronic forms, where the exudation takes place deep in the corium, that the thickening and infiltration so characteristic of the disease are found. When not too great it can be fully appreciated by pinching alternately the healthy and the diseased skin; but in some inveterate cases the skin is so densely infiltrated that it cannot be pinched up. If it is so situated that the natural movements of the part subject the infiltrated skin to stretching, painful fissures and excoriations are produced, which are often very difficult to heal.

(4) *Itching, etc.*—The subjective symptoms of eczema are perhaps the most important of any, both on account of the great distress they cause and of the influence they exert in keeping up the disease. These symptoms vary greatly in the different cases and in the different forms of the disease, and even at different times in the same individual. In some cases there is merely a slight tingling or pricking sensation, or feeling of formication, while in the other extreme there may be most intense itching, which can be relieved only by deep and continuous scratching with the nails until a bleeding or oozing surface is produced. Between these two extremes various degrees of irritation are experienced. Sometimes, as in the acute and erythematous forms, smarting or burning is alone complained of. In other cases this amounts to a burning pain, without any itching or desire to scratch. The itching of eczema is, as a rule, paroxysmal or

intermittent in character, aggravated generally by exposure to the air, and invariably worse at night. Its character and intensity are likewise affected by the influences already mentioned, as having a bearing upon the general symptoms of eczema. Besides the itching or some of its modifications just enumerated, certain patients exhibit a most marked hyperesthesia of the skin, particularly upon exposure to the air or the slightest contact of the clothing, and when certain remedies are applied to the skin.

In addition to the symptoms just described, certain characteristics in the course and evolution of the disease are common to all cases of eczema. The clinical picture varies from day to day, and in some cases, especially in children and infants, from hour to hour. Not only rapid changes in the severity of the process are to be expected, but the type of the eruption itself may change in a very short period of time. The reason for this will be apparent when we come to consider the various causes of the disease. Eczema either runs an acute course, remaining for a few weeks or a month when recovery takes place; or, as more commonly happens, it becomes chronic and may last for years or for a lifetime. It may be limited to only one region of the body or of an extremity, but more frequently it occurs in several localities, and generally in a symmetrical manner. Often the disease is more or less general in its distribution, and in rare instances it becomes universal. Its general tendency in every case is to progress, and spontaneous recovery is not to be looked for. No matter how severe or protracted the disease may be, there are usually no constitutional symptoms, although in the worst cases some impairment of the general health is manifested as a result of the persistent loss of sleep and prolonged suffering.

Eczema is so varied in its manifestations and so protean in character that to give a comprehensive clinical picture of the disease would obviously be impossible. It is necessary, therefore, in the further study of its symptomatology, to consider separately the various types of eruption which make up the symptom-complex of the affection. While this is essential for a clear understanding of the disease as a whole, it must not be forgotten that the several types about to be discussed rarely occur clinically in a distinct or pure form, but are often mingled one with another, or follow one another in rapid succession. This frequent and often very rapid change in the severity of the process and in the type of lesion has already been referred to as one of the chief characteristics of the disease.

For convenience of description the subject is divided in the following manner:

(A) Types of the eruption dependent upon the predominant, primary, anatomical lesion, namely, *eczema erythematosum, eczema papulosum, eczema vesiculosum,* and *eczema pustulosum.*

(B) Types dependent upon secondary changes in the preceding, namely, *eczema rubrum* or *madidans, eczema squamosum, eczema sclerosum, eczema verrucosum,* and *eczema fissum,* and

(C) Types dependent upon the stage or character of the inflammatory process, namely, *eczema acutum* and *eczema chronicum.*

The symptomatology, diagnosis, and treatment of the other special varieties of the disease, namely, *eczema infantile, eczema parasiticum, eczema seborrhoicum,* and the regional forms of eczema will be considered separately.

A Types.—*Eczema Erythematosum.*—This type of the disease occurs in its most characteristic form upon the face in middle-aged or elderly people, though it may affect any part of the body. It generally begins in small, irregularly shaped patches, of a more or less bright red color, which coalesce into larger areas. The face, however, may be acutely suffused, in which case there is considerable edema, with closing of the lids and marked temporary disfigurement. When the affection is acute, after a few hours tiny vesicles develop upon the erythematous surface and some moisture or oozing is produced by the rubbing, which is resorted to in consequence of the itching. In the subacute form the color is a dull red, and slight scaling is to be observed, while in the chronic forms considerable thickening of the skin is produced, the natural lines being greatly exaggerated; the color in the more chronic forms varies from a dull red to a purple or brown and the scaling is more abundant. Itching and burning are the chief symptoms complained of, the former being so severe, especially when the disease is chronic, that the eyebrows are sometimes rubbed off in the efforts of the patient to obtain relief. The disease may be of very short duration, or may last for years, with intervals of slight improvement; this form is often spoken of as "*chronic erysipelas.*" Erythematous eczema of the extremities presents characters similar to those upon the face, though the scaling is apt to be more abundant, and here the type readily changes into the squamous form.

When it occurs upon the palms and soles the skin is thickened, red, and swollen, and it is accompanied by most intense itching and burning. In the axillæ, beneath and between the breasts, or in the fold of the neck and groins in infants, the disease is of a brighter red color, and a moist oozing surface is produced. This form of eruption constitutes "*eczema intertrigo.*"

*Eczema Papulosum.*—The papular type of eczema is of very frequent occurrence, and is often one of the most obstinate forms met with. It is characterized by the appearance of firm, dull red, acuminate or rounded raised papules, varying in size from a mere speck to that of a pin's head. These may develop in a discrete manner, scattered irregularly over the part affected without tendency to grouping, or form here and there into small groups or even coalesce into patches. When located about the hair follicles a lichen-like appearance is presented, and on this account the disease was formerly called "*lichen simplex.*" The number of lesions present at any given time varies considerably. Often they are sparsely distributed, but after a time the itching becomes so intense that new papules develop rapidly in consequence of the severe scratching induced. These are soon capped by small blood crusts or are severely torn, so that serum oozes from their summits. There is perhaps no other variety of eczema in which the itching is such a marked feature.

The disease may remain papular throughout or the papules may develop into small vesicles and then into pustules, or become associated with other vesicular or pustular lesions. When they are grouped, or become more or less confluent, weeping patches with infiltration and crusting may form as a result of vigorous scratching. Sometimes the lesions present the flat character of those seen in lichen planus, and the color being dull red or purplish, mistakes in diagnosis are not uncommon. This form of papule generally occurs about the neck and flexor surfaces of the wrists, both common sites for lichen planus.

The life history of any individual lesion or group of lesions is extremely variable. The same papule may remain almost unchanged for weeks or may disappear quickly, only to be replaced by others in rapid succession. Sometimes a single small patch or several patches, without any other manifestation, will affect some particular location and resist the most careful treatment for long periods of time.

The distribution of the eruption is of considerable importance, particularly as regards diagnosis. The trunk, especially the back and buttocks, and the flexor surfaces of the arms, forearms, thighs, and legs are the regions generally affected. It rarely occurs upon the face, hands, or feet. The disease is more

common in adults than in children or infants, the liability being about the same for both sexes.

*Eczema Vesiculosum.*—Vesicular eczema pure and simple is perhaps less commonly observed than any other type of the disease. It is essentially an acute process and speedily changes into some other form, or is associated with some more chronic variety. The attack is always preceded by tingling, pricking, or itching sensations, which are soon followed by a punctate or diffuse erythema, with more or less swelling of the tissues. After a few hours a number of tiny vesicles appear upon the reddened surface, which vary in size from a pin's point to a pin's head. These are pearly and transparent and have a very thin covering of epidermis. In some localities, as between the fingers and toes, and on their flexor surfaces, or on the palms and soles, which are the most common sites of the eruption, the erythematous stage is often wanting, the lesions appearing as minute transparent globules embedded in the skin. There is generally no tendency to grouping of the vesicles in this type of the disease, though they are closely packed together and sometimes even coalesce. In a very short time, even after the lapse of only a few hours, they either rupture spontaneously or are broken by the patient in scratching. Much relief from the itching is now experienced, but this symptom is quickly replaced by smarting or burning. The contents of the vesicles soon moisten the affected part, which is kept more or less wet by the oozing of serum from the vessels beneath, or is converted into a moist crusted patch. The serous crusts which form are of a characteristic yellowish color, and are never very thick. In some cases the crusts are continually washed away or are removed by contact with the clothing, leaving a red, angry, oozing surface, being thus converted into an "*eczema rubrum*" or "*eczema madidans.*" At other times the weeping diminishes and a scaly, red, infiltrated patch results, "*eczema squamosum.*" Under appropriate treatment, however, neither of these secondary forms develops, but resolution takes place by a gradual subsidence of all the symptoms. New vesicles cease to appear, the oozing becomes less and less, the surface heals beneath the crusts, and there is left a sensitive, slightly reddened skin, which in a few days becomes normal. Besides the secondary forms of eczema just referred to, into which the vesicular type of the eruption may develop, secondary inoculation frequently takes place with the production of a pustular eczema.

It must likewise be remembered that vesicular eczema is often associated with the other primary forms, appearing as an acute outbreak at some time during their course. In addition to the sites already mentioned, the disease may develop upon the face, on the flexor surfaces of the forearms and thighs, and less commonly upon various parts of the trunk; it is seldom, however, general in its distribution.

*Eczema Pustulosum.*—This type of the disease, which is sometimes called "*eczema impetiginosum,*" usually begins in one of the preceding forms, the character of which is changed either by an increased intensity of the inflammation or by secondary infection with pus germs. It is possible for the eruption to develop *de novo*, but this is quite the exception. Any diseased condition or physiological state that will diminish the natural skin resistance against the incursion of pathogenic organisms predisposes to this form of eczema. It is therefore more common in infants, especially in the strumous and ill-nourished, and in elderly people. It is seen in its most characteristic form upon the head and face of infants, where from very early times it has been known as "*crusta lactea,*" or the "*milk crust eruption.*"

It generally begins in a group of papules or an erythematous patch, which speedily becomes moist and crusted from the subsequent development of vesicles. Infection soon takes place from the wounding of the surface by the nails, and thick greenish crusts form, which, when matted with the hair on the scalp, emit a most nauseous odor. It usually occurs symmetrically on both cheeks and around the ears, but in very bad cases may cover the entire head. In elderly people it is most frequently observed upon the lower legs, where it may affect only the region around the ankles or may cover the entire leg with thick, dirty greenish crusts.

Pustular eczema may also attack the bearded face and the hairy region of the thighs, in which case it must be differentiated from sycosis and folliculitis. Eczema, however, is never confined to the follicles, but also affects the intervening skin and often spreads to non-hairy parts.

The itching of pustular eczema is less marked than in some of the other varieties of the affection. Except in very rare instances, in which deep wounds have been made, this eruption is never followed by scarring or permanent loss of hair.

B Types.—*Eczema Rubrum or Eczema Madidans.*—Eczema rubrum may develop from any of the preceding varieties, but, as already mentioned, most commonly follows vesicular or pustular eczema. It often results in consequence of improper treatment. The patient's occupation or his injudicious care of the eruption may likewise be responsible.

It is characterized by intensely red, inflammatory patches, or diffuse areas which continuously exude a clear serum that subsequently dries into brownish or green crusts of variable thickness. These in turn are loosened by the accumulation of serum beneath, or are forcibly removed by contact with the clothing, producing an intensely red, infiltrated, and continuously weeping surface. This constitutes one of the most distressing forms of eczema, as it is generally chronic in its course and the subjects of it suffer intense pain most of the time.

It is especially common upon the lower legs of elderly people and often covers the entire leg, accompanied by much edema and great infiltration. It also occurs on other parts of the body, particularly in regions where there are heat and moisture, as in the axillæ, in the folds of the breasts, nates, etc.

*Eczema Squamosum.*—While in the preceding variety of eczema the peculiar clinical symptoms are due to the great intensity of the inflammatory process, in this, the squamous form, the acute catarrhal characters are in abeyance. By a subsidence of the discharge and a diminution in intensity of the inflammatory symptoms, eczema rubrum may subsequently become squamous eczema. It is more commonly, however, a sequel of eczema erythematosum, but is often an intermediate form occurring at some time during the involution of some of the other primary types. Papular eczema, by coalescence of the lesions, may likewise develop into this form of eruption. Squamous eczema generally appears in variously sized, irregularly outlined patches, some oval, some elongated, and when of long duration quite sharply defined. The color is a dull red, and there are always considerable infiltration and scaling.

The scales are not large and flaky and are not firmly attached as in psoriasis, but usually brush off quite readily.

When the affected skin is irritated by severe scratching, a weeping surface may result with the production of serous crusts, an event that is liable to occur in any form of eczema. The most common localities for squamous eczema are the scalp, face, and back of the neck. Patches of the disease are also frequently observed on the outer surfaces of the arms, on the extensor surfaces of the thighs and legs, and sometimes upon the trunk.

*Eczema Sclerosum.*—This clinical type is observed practically only upon the palms and soles. It begins as an ordinary eczema of these parts which becomes

chronic and results in great thickening of the tissues. The epidermis presents a calloused appearance, and is often so hard and stiff that flexion of the hands or fingers is rendered impossible. In those who labor with their hands the disease is seen in its highest development. In simulates very closely the symmetrical keratoses, either hereditary or acquired, but is always readily distinguished by the fact of there being a pre-existing eczematous condition.

*Eczema Verrucosum.*—As the name implies, this is a warty form of eczema. Besides the induration and thickening there is papillary hypertrophy resulting in a rough, warty surface that bears very little resemblance to an eczema.

The most characteristic examples of verrucous eczema are seen upon the lower legs, where it sometimes attains such a high state of development as to resemble an elephantiasic condition. The natural contour of the limb is generally destroyed and the diseased surface emits a sickening odor from decomposing secretions retained in the deep sulci between the warty growths. This form of eczema occurs also in other localities, as in the axillæ, about the genitals, beneath pendulous breasts, etc., wherever, in fact, heat, moisture, and uncleanliness favor epidermic and papillary hypertrophy.

*Eczema Fissum.*—Any eczema affecting regions in which the skin, from its anatomical position, is subjected to more or less movement or stretching, is very prone to develop rhagades or fissures; this complication constitutes eczema fissum, or "*eczema rimosum.*" The eczematous process renders the skin inelastic and it cracks very readily. These fissures may extend only through the epidermis, but generally they go much deeper, even penetrating the upper part of the corium. They are extremely painful, bleed very easily, and often last a long time, if so situated that the part cannot be immobilized. Fissures may complicate any of the primary forms of eczema, although the erythematous and papular types are more liable to develop these secondary changes. Eczema fissum is most commonly seen upon the palms of the hands and soles of the feet where it frequently results from an eczema sclerosum, upon the flexor surfaces and tips of the fingers, behind the ears, and in the flexures of the limbs. It is likewise often observed at the junction of the skin and mucous surfaces, as the corners of the mouth and around the anus.

The condition commonly known as *chaps* or *chapping* may or may not be associated with eczema. It very frequently occurs in those having delicate skins, but having no history of eczema nor a tendency to that condition. It results from the action of irritating soaps, excessive use of hot water, exposure to cold winds, etc.

C Types.—*Eczema Acutum* and *Eczema Chronicum.*—This is a very important division of the subject, especially from a therapeutic standpoint. The term acute eczema refers both to the intensity or inflammatory character of the eruption and to its duration. We call an eczema acute when it begins suddenly with redness and swelling, accompanied by an itching, burning, or tingling sensation. It may appear in one or several localities, or may spread from one focus over an entire limb or large area of the body. It may remain an erythematous eczema or papules, vesicles, or pustules may develop resulting in weeping patches or scaly and crusted areas. It often presents many characters of a simple dermatitis, but if the affected skin is carefully protected and treated by soothing remedies, the disease slowly subsides and the attack is of comparatively short duration. On the other hand, this same character of eruption may extend over long periods of time with alternating intervals of quiescence and acute exacerbation, so that while the disease in such cases may be justly called chronic, the eruption is always acute in character, and must be so considered in its therapeutic management.

Chronic eczema, clinically speaking, is characterized on the contrary by infiltration and thickening of the tissues, and generally occurs in the form of thickened, scaly, dull red patches or infiltrated areas of varied extent. It may affect any given locality as the scrotum, bend of the elbows and knees, etc., and may resist treatment for years; or it may become fairly universal, the entire skin being greatly thickened and scaly, the natural lines exaggerated, the whole of a dull red color, and imparting a distinct leathery sensation to the touch. The itching is often so intense that the hairs are rubbed off in efforts to obtain relief, or secondary changes take place as a result of the vigorous scratching to which the skin is subjected. Fissures and cracks, already referred to, are a common complication, as are also furuncles and ecthymatous lesions, and various secondary manifestations due to inoculation with pathogenic germs. The most stimulating and revulsive measures are often necessary in the treatment of the eruption in this stage. It must not be forgotten, however, that an eruption of an acute type may develop from time to time during the course of a chronic eczema, necessitating the employment of only the most soothing remedies.

Besides the acute and chronic stages of eczema, there is a subacute form which occupies both clinically and therapeutically an intermediate position. Very many of the patients who apply for treatment present an eruption of this character, but, with a clear knowledge of the clinical features of acute and chronic eczema, the physician will find no difficulty in recognizing the disease in its intervening stages.

Pathology.—The pathological changes in eczema are those of ordinary inflammation. That it is a catarrhal inflammation of the skin, similar to that affecting mucous membranes, is conceded to-day by most observers, and the pathological findings in the majority of cases certainly lend support to this view. Duhring, however, thinks we ought not to insist too strongly on this point, inasmuch as many of the manifestations of eczema differ from those observed on mucous membranes. The causes operative in the production of the skin changes are far from clear, in spite of the great advances made in cutaneous pathology during the past ten or fifteen years. There is, in the first place, something in the skin of an eczematous subject that renders it susceptible to the action of irritants of either local or internal origin. What this is we do not know, but presume it to be some nutritional defect. What the exciting cause is that sets up the inflammatory changes in this impaired or weakened skin is yet to be ascertained. Much has been done in recent years in the study of microorganisms in connection with this disease, but it still remains unproven that any particular parasite is the exciting cause of eczema. It seems much more plausible, considering the varied etiology of eczema, and its dependence in most cases upon constitutional derangements of one form or another, to regard toxins circulating in the blood as a probable exciting factor in the production of the lesions.

Crocker is inclined to believe with Hebra and Tilbury Fox that eczema, when not due to local irritants, is a trophoneurosis, either central or peripheral. In support of this view are the cases in which inflammatory changes have been observed in the nerves supplying an eczematous patch. In a Symposium on Eczema at the annual meeting of the American Dermatological Association in 1912 it was clearly shown that little or nothing had been added to our knowledge of the pathology or causes of eczema in the past fifteen years.

Pathological Anatomy.—The morbid anatomy of eczema, as already mentioned, is that of ordinary

inflammation, consisting in hyperemia, dilatation of the blood-vessels of the corium, exudation of serum resulting in edematous swelling, and diapedesis of white blood cells.

There are also connective-tissue cell proliferation and degeneration of the rete cells. These changes vary according to the stage of the disease. In acute eczema the inflammation is diffuse except in the papular form, when it is more circumscribed. The primary changes are in the papillary layer, from which they extend to the epidermis, to the deeper parts of the corium, and in some cases even to the subcutaneous fatty tissue. They consist in blood-vessel dilatation, serous exudation, and diapedesis of the white corpuscles. The detritus resulting from the destruction or degeneration of the rete cells mingles with the serum to increase the edema. Vesicles in acute eczema are situated in the upper part of the rete. The cells degenerate with the formation of spaces between the nucleus and protoplasm, which enlarge into a cavity containing serum, cell fragments, and fibrin. When the exudate is excessive, the horny layer is raised from the rete, forming bullæ or large vesicles.

If there is an extensive cell degeneration, the cavity of the vesicle is filled with leucocytes and is converted into a pustule; here pus organisms are always to be found. In eczema rubrum there is, instead of the formation of vesicles or bullæ, an entire removal of the horny layer, which, on account of deficient keratinization, is not restored, leaving the corium exposed. In acute papular eczema the changes are limited to a circumscribed area and, according to Robinson, take place primarily around the follicles, especially the hair follicles.

The morbid changes in chronic eczema consist in an hypertrophy of the rete, an enlargement and lengthening of the papillæ, and a thickening of the corium by an enormous proliferation of connective-tissue cells. In some cases the tissues may become so dense as to result in lymphatic obstruction and elephantiasic changes. The glandular structures, as well as the hair follicles, may become atrophied or even entirely destroyed in the more chronic forms of the disease.

Etiology.—Eczema at the time of the second edition of this work constituted in this country about one-third of all cutaneous affections, but the statistics of the American Dermatological Association for 1913 show that now eczema comprises only eighteen to twenty per cent. of all skin affections. Advances made in cutaneous medicine in recent years are responsible for this great reduction in frequency of eczema. It still remains, however, the most important disease of the skin which the general physician is called upon to treat to-day. It affects men and women in about equal proportion and occurs at any age from the earliest weeks of life to old age. The greater number of cases are observed between the ages of twenty and forty, the period of greatest activity in most people's lives. The disease is never inherited in the true sense of the term, but, as in the case of so many other troubles, a tendency or predisposition to eczema may be inherited. In such the disease is readily lighted up, often by the most trivial agencies, that would not be deleterious in any way to most persons.

Eczema, as far as we know, is not a contagious disease, though certain forms are parasitic in nature; some of these latter are autoinoculable.

The causes of the disease may be conveniently arranged under two headings, those of *internal* or *constitutional origin*, and *external* or *local causes*. No single cause is ever responsible for a given attack of eczema, its etiology is distinctly a complex one, and while this division is made for the sake of convenience, it must be understood that the two classes of causative factors often act conjointly.

*Constitutional Causes.*—Eczema is a disease of debility; no healthy individual, in my opinion, ever suffered an attack of eczema. Even in those cases in which the disease is dependent upon local causes alone, there is always some constitutional defect which enables these causes to become operative. My views in regard to the nature of eczema conform, in a measure, to those held by Erasmus Wilson. He considered the disease one of *debility*, either "*assimilative*," "*nutritive*," or "*nervous*." As far as it goes, this, I think, is the true conception of the nature of eczema.

Foremost among the constitutional causes of eczema are those dependent upon disorders of the gastrointestinal tract. Dyspepsia in its various forms, constipated or irregular bowel action, intestinal and gastric flatulency, sluggish or disordered liver action, all these impair the general health and affect the nutrition of the skin. Improper and insufficient food, errors in diet, etc., while perhaps not affecting the gastric function, do debilitate the system and weaken the resisting power of the skin. In infants, these latter are the direct exciting causes of the eczema in a great majority of the cases, and are, therefore, of the very greatest importance in the management of infantile eczema. The ingestion of certain drugs, as arsenic, mercury, iodide of potassium, etc., is capable of bringing forth an eczema in certain individuals. I have only recently had under my care a case of generalized eczema due to the internal administration of mercury in the treatment of syphilis. This is to be distinguished from the cases of mercurial dermatitis that are occasionally observed, and the various types of pure drug eruptions.

That there is a causative relation between the so-called gouty state and eczema there can be no question. The association of both rheumatism and gout with some form of eczematous disease is a matter of frequent observation. It is true that many sufferers from chronic gout or rheumatism never have eczema, but, *per contra*, these conditions are frequently observed to stand in a direct causative relation to the disease. Cases, for instance, have been observed in which an attack of constitutional gout has been relieved immediately upon the outbreak of an eczema, and patients remain free as long as the eczema lasts. It is also interesting to note the frequency with which we find a history of gout, rheumatism, chronic bronchitis, asthma, etc., in the antecedents of eczematous patients. In every eczema in middle-aged or elderly people the possibility of a gouty origin should be borne in mind.

Various disorders of the nervous system are potent factors in producing and keeping up an attack of eczema. This is not surprising when one considers the abundant nerve supply of the skin, the intricate and special termination of the nerve filaments, and the very delicate mechanism which governs, through the vasomotor nerves, the blood supply of this great organ. The most common condition observed in this connection is that of nervous exhaustion due to overwork, anxiety, excesses of various kinds, or direct shock of the nervous centers. Examples of neurotic eczema dependent upon one or another of these conditions are of very frequent observation. A recognition of the etiological relations in this class of cases is essential for the successful management of the disease.

The derangements or the nervous system in lithemic subjects, as well as in those suffering from gastric, hepatic, or intestinal disturbances already referred to, deserve mention in this place. A train of nervous phenomena is sometimes engendered which reacts upon the original disorder, and thus a vicious circle may be established which is a powerful factor in causing or aggravating an existing eczema. Among other disorders of the nervous system may be mentioned direct injury to the nerves themselves, and also

neuritis and some neuralgias. These have all been directly responsible for an eczematous outbreak.

Besides the causes just enumerated certain physiological states and functional or organic disease of remote organs may cause eczema through the influence of the reflexes. Among these may be mentioned pregnancy, lactation, the climacteric, dentition, retained smegma, misplacements, tumors or congestions of the uterus, movable kidney, etc. The intimate relation between asthma and eczema in certain instances has been noted by a number of observers. The two may coexist in the same individual or eczema may alternate with the asthmatic paroxysms. It is not known what the true relation is between them, but their association is frequently enough observed to warrant mention. An interesting instance of this came under my own observation. The mother of a family of four children, two sons and two daughters, suffered from asthma and eczema. One of the children (the eldest son) was also a subject of both asthma and eczema, and his daughter, an only child, was hopelessly crippled in consequence of an inveterate asthma, and she was likewise a sufferer from eczema.

Diabetes may also be considered a cause of eczema. An eczematous eruption frequently develops about the genitals in diabetic subjects, but in many cases this disappears upon removing the sugar from the urine. In these cases the eruption would be more properly classed as a dermatitis. In a certain number, however, the eruption persists as an eczema and may develop elsewhere upon the body.

In concluding the consideration of the constitutional causes of eczema it is only necessary to mention that chlorosis, malaria, tuberculosis, or any systemic disorder which lowers the general nutrition, may stand in an etiological relation to the disease.

*Local Causes.*—The agencies that may excite an eczema by their action externally upon the skin are exceedingly numerous and at the same time very important. Their actual position and importance as causative factors, however, are still subjects of considerable controversy. There are those, notably the pupils of the German school of dermatology, who regard them as the prime factors in the etiology of the disease, while other equally distinguished dermatologists consider them of altogether secondary importance. I believe that, for the successful treatment and management of eczema, it is essential to weigh fully every condition or agent that may stand in any way as a causative factor in the disease, whether of external or internal origin. I attribute very great importance to both classes of causes, for to be operative it is often necessary that they should act conjointly. I have already said that I did not believe a healthy person ever suffered from eczema; nevertheless, to call forth the disease an exciting cause is necessary, whether it acts from without or within the economy. Eczema is never engendered through the action of local causes alone, there is something else necessary, call it predisposition if you will, but there is, in my opinion, always some contributing factor which stamps the eczematous character upon the eruption thus excited.

It would not be possible to enumerate all the local causes of eczema. They usually comprise, however, three classes of agents, namely, those of a thermal, mechanical, or chemical nature.

The *thermal* agents, heat and cold, are sometimes important factors in the evolution of the disease. Both solar heat, either direct or reflected from water, and the artificial heat to which laundresses, cooks, stokers, firemen, etc., are subjected may be responsible. The first constitutes "*eczema solare*," and should be distinguished from erythema solare or sunburn which is a simple dermatitis. "*Eczema intertrigo*," which develops in fat people and in infants through the action of heat upon moist surfaces, in the various folds of the body, must likewise be distinguished from erythema intertrigo. The action of cold in the production or aggravation of eczema is of common observation. This applies to climatic changes, including the action of cold winds, and to the contact of cold substances. Eczema is almost always worse in winter, and sudden changes from warm to cold may excite the disease or aggravate an existing eruption. I have had occasion to see a number of cases of eczema of the nails and surrounding tissues in ice-cream workers, who in the course of their work were compelled alternately to put their hands into very hot water and then into freezing mixtures.

Among the *mechanical* causes may be mentioned pressure and friction by either the clothing or such extraneous objects as trusses, braces, artificial limbs, etc., the dust and dirt incident to certain occupations, and traumatism of various kinds including scratching. Scratching is one of the most important of the local causes of eczema. There may be a pruritus as an early symptom of the disease or the itching may result from an urticaria, or from the bites of insects, such as fleas, pediculi, mosquitos, itch-mites, bedbugs, etc. The prurigo of Hebra is often complicated by an eczema induced by scratching. Scratching will also invariably aggravate an existing eczema and cause it to spread rapidly.

Water used either too hot or too cold, as in the Turkish and Russian baths, is an exciting cause of eczema in a certain number of cases, and the washing of an eczematous surface almost invariably increases the trouble.

Vaccination will often cause the eruption to develop in one subject to the disease or having a predisposition to the same. I do not believe, however, that it is ever solely responsible for the disease, though it is generally regarded so by the laity.

The *chemical* agents that may produce eczema are very numerous, and only a few of them can be mentioned. The most common are the various acids and alkalies, strongly alkaline soaps, mercurial frictions, sulphur, arnica, alcohol, ether, chloroform, turpentine, iodine, iodoform, etc. The different dye-stuffs and the various chemicals used in the trades are responsible for many of the so-called trade eczemas. Bricklayers, masons, printers, washerwomen, photographers, bleachers, dyers, and painters are often thus affected. Cooks and bakers may suffer from eczema caused by the action of the sugar, alum, borax, etc., used in making bread and pastry. Bartenders, waitresses and waiters, bottle-washers, and cigar-makers are others who sometimes suffer from trade eczema. Exposure to poison ivy, or *Rhus toxicodendron*, and also to poison sumac, and some other poisonous plants will produce eczema in some individuals.

Animal and vegetable parasites may likewise be regarded as causes of eczema, and microorganisms which are known to produce special types of skin lesions may possibly be responsible for some forms. Satisfactory proof, however, of the causative relation of any form of microorganism to eczema has not yet been obtained.

Any one of the agents above-mentioned is capable of causing a skin eruption of greater or lesser severity. This may wholly subside upon removal of the cause and would then be regarded as an artificial dermatitis. In a certain number, however, the eruption persists and continues to spread and even develop in remote places long after the cause which excited it has ceased to operate. This latter is eczema, and any local irritant that acts in this way does so in a subject who is predisposed to the disease. The predisposition may be hereditary or acquired, but without it a true eczema will not be produced. One has only to study closely a few cases of trade eczema to be convinced of this. It is a very common thing to hear patients

suffering from a severe eczema of this kind say that they have worked for years at the same trade, but never before had anything more than a slight irritation.

In summing up the causes of eczema it will readily be seen that the etiology of the disease is a very complex one. This would account for the rapid changes in the severity of the process and the great multiformity in the type of the lesions, as already referred to while considering the general symptomatology.

Diagnosis.—The diagnosis of eczema is, as a rule, comparatively easy. The disease is so common that the ordinary types of the eruption are readily recognized by most physicians. I think the mistake of diagnosing some other affection as eczema is more often made than that of failing to recognize the disease when it is present. In some of the mixed forms, however, the diagnosis is often attended with the greatest difficulty, and even the expert is occasionally deceived in differentiating eczema from some of the rarer affections of the skin. It must also be remembered that eczema is often found associated with some other skin affection, and the greatest care is sometimes necessary in differentiating them.

The diagnosis of the special forms and local varieties will be considered when we come to study these later on. In this place the differential diagnosis will be made between eczema and the affections for which it is more liable to be mistaken.

*Erysipelas.*—This is an acute febrile disease, usually accompanied by severe constitutional symptoms; these alone will distinguish it from eczema. The disease begins at one point and spreads very rapidly, the area affected presenting a well-defined margin; the surface of the part thus affected has a shining, tense appearance, is reddened and swollen, and feels very hot to the touch. Eczema spreads more slowly, often begins at several points, is ill-defined, and the surface is roughened and scaly, very little swollen, and does not feel very hot. Pain and burning are complained of in erysipelas, while eczema generally itches. Vesicles may develop upon a patch of erysipelas, but they are larger than those in eczema, even attaining in some cases the size of bullæ. Erysipelas of the face, if at all extensive, is almost sure to extend up over the forehead into the scalp. Erythematous eczema in this situation does not extend beyond the hair border. Eczema rubrum is sometimes mistaken for erysipelas of the leg and is often wrongly spoken of as "*chronic erysipelas.*" The absence of the constitutional symptoms and clinical characters stated above, its chronic course, and its tendency to weep and form crusts are distinguishing features.

*Erythema.*—*Erythema simplex* is an acute evanescent eruption and would rarely be mistaken for eczema. There is neither scaling nor swelling of the tissues, and the itching and usual symptoms of eczema are wanting. Sometimes an erythema will persist, becoming chronic, but it maintains the same hyperemic character, though of a passive nature, lacking all the clinical symptoms of eczema. *Erythema multiforme* itches but slightly, generally begins upon the back of the hands and forearms, the papules are larger and more succulent than those of eczema, and there is often a history of recurrence with the change of the seasons. *Erythema scarlatiniforme* simulates acute generalized eczema, but the outbreak is preceded by prodromal symptoms of general malaise, backache, slight fever, etc., which are absent in eczema. It generally begins with more or less diffuse redness and swelling, accompanied by burning and tingling and on about the fourth day commences to desquamate. This is fine and branny upon the limbs and face, but large flakes are shed from the trunk, palms, and soles. It likewise lacks the weeping catarrhal characters of eczema.

*Lupus Erythematosus.*—This disease often bears a very close resemblance to erythematous eczema, and mistakes in diagnosis are frequent. Lupus erythematosus, however, is more chronic in its course than eczema, and while it also appears most commonly upon the face, it occurs in variously sized, irregularly outlined, well defined infiltrated patches of a dull red color, bearing thin but quite firmly attached scales. The patches of eczema are not well-defined, the infiltration is less marked, and the scales are loosely attached. If the scales in lupus erythematosus are forcibly removed, there are numerous tiny plugs attached to them, which fit into corresponding openings of the sebaceous follicles; this is never seen in eczema. The itching is very slight in erythematous lupus, and there are no vesicles or weeping areas as seen in eczema. The eruption is also generally symmetrical in its distribution, and smaller foci are frequently seen upon the lobes of the ears and on the scalp. Finally, small white atrophic scars form sooner or later in every case —a manifestation entirely foreign to eczema.

*Acne Rosacea.*—This form of acne is confined to the middle zone of the face, including the nose, and adjacent part of the cheeks, the chin, and forehead, while eczema is more diffuse. The eyelids are never affected as in eczema, the color is a brighter red, and there is generally no itching. The surface temperature is cool, while that of eczema is increased and the infiltration is less than in eczema. Telangiectases are generally present, together with pustules and indurated papules which are not seen in eczema of this region. Often a seborrheic dermatitis is subjoined which is generally associated with more or less dandruff in the scalp and seborrhea oleosa about the nose and forehead. Little difficulty should be experienced in recognizing this complication. Acne rosacea is a disease of middle or advanced life, while eczema may occur at any age.

*Urticaria.*—Papular urticaria, a form of the disease frequently observed in children, often bears a close resemblance to papular eczema. The papules in urticaria, however, are scattered without tendency to confluence or grouping, and are comparatively short-lived. When scratched they often swell, and wheals or erythematous spots appear from time to time, which would distinguish the disease from eczema.

*Lichen Planus.*—Eczema is perhaps more often confounded with lichen planus than with any other disease. The papules of lichen planus, however, are distinctive in character. They are angular in outline, flat and shining, slightly scaly, often umbilicated, and of a dull red or purplish color. The eczema papule is acuminate or has a round top with circular base, and has a bright red color. Lichen planus papules develop slowly, increase in size, often becoming quite large, but they never lose their characteristic form, and when they disappear leave a well-marked pigmentation. The eczema papule develops quickly, frequently undergoes change in form and character, and disappears without pigmentation. Lichen planus papules have a peculiarity of developing along a scratch, a feature not often observed in eczema. The patches of lichen planus are more irregular in outline than those of chronic eczema, and often appear in a linear form; the characteristic papules making up the patch are generally to be seen at the periphery. Lichen planus has a predilection for the flexor surfaces of the wrists and forearms and inner side of the knees and thighs, while the patchy form is more commonly seen upon the back or sides of the neck and on the lower legs.

*Pityriasis Rubra Pilaris.*—This affection is almost invariably mistaken for eczema by the general practitioner, for it is of rather rare occurrence and is seldom seen outside of dermatological practice. It is a very chronic disease, and extends over a period of many years. The distinguishing lesions are small, hard, yellowish or red, horny, conical papules, each of which is located at the orifice of a hair follicle. They

impart to the hand passed over them the sensation produced by a nutmeg grater. These are especially prominent on the arms, forearms, thighs, and the dorsal surface of the phalanges. In the last-named location they appear as hard, black points, and when present are a certain diagnostic sign. There is nothing in eczema resembling these lesions. The disease may become generalized and then resembles squamous eczema; it may even become universal, but there are never any signs of scratching as in eczema. The skin is uniformly dull red, infiltrated, and covered with fine, horny scales. Eczema is a brighter red, the scales are larger, and somewhere there is generally evidence of scratching with oozing or crust formation. There is also a severe symmetrical hyperkeratosis of the palms and soles, and great thickening of the nails —features not generally observed in eczema.

*Psoriasis.*—The average case of psoriasis offers no difficulties in diagnosis from eczema. The patches are sharply defined, are covered with dry micaceous imbricated scales, are generally seen in the neighborhood of the elbow or knee, and show a preference for the extensor surfaces of the limbs. The patches of eczema are ill-defined, the crusts are darker, and are composed of dried serum mingled with epidermic scales, and they show preference for the flexor surfaces. Removal of psoriatic scales reveals numerous punctate hemorrhages, while beneath the eczema crust is a red, oozing surface. Psoriasis is always a dry eruption; eczema, even in the dry squamous form, shows catarrhal tendencies at times as a result of scratching or traumatism. The subjects of psoriasis are almost always in robust health, while eczema patients are often in ill health. The history of long duration and relapses in psoriasis is often of much service in diagnosis. Psoriasis of the scalp resembles eczema closely at times, but the eruption is drier, presents a patchy character instead of being more or less diffuse, and where it extends beyond the hair, as upon the forehead, the eruption has a sharp margin which would distinguish it from eczema. Some patches of chronic infiltrated eczema resemble those of psoriasis very closely, but they are not apt to be so sharply defined, the itching is more intense, they often become wet by scratching or rubbing, and crusts of dried blood and serum form at times. Small guttate psoriasis is sometimes mistaken for papular eczema, but scraping off the scale with the nail will usually reveal the small bleeding points; this, together with a careful examination as to the localization of the lesions and the history of the disease, will generally enable one to make the correct diagnosis.

*Syphilis.*—Some of the syphilodermata resemble eczema quite closely, and mistakes in diagnosis are not infrequently made. The lesions of the small papular syphiloderm generally show a tendency to grouping, often in the form of crescents or segments of a circle. Papular eczema lacks this characteristic. The color of the syphilitic papule is dull red instead of bright red as in eczema, and it is hard and shot-like to the touch, while in eczema the papule is not so firm. There is rarely itching in papular syphilis, while the itching in papular eczema is generally intense.

The pustular syphiloderm, especially that upon the scalp, is difficult sometimes to distinguish from eczema pustulosa. The syphiloderm, however, soon forms scabs, which when removed reveal a small, sharply cut ulcer, and eventually it leaves a scar. Upon removing the crusts of pustular eczema, a smooth, red, moist surface remains, and there is never any ulcer or scar formation. Squamous papular syphilis of the palms and soles is often mistaken for eczema, but it presents a circinate, sharply defined border, which by close inspection is found to be made up of separate papules which have fused together. Eczema in these regions forms a uniformly scaly patch, usually lacking the sharp definition, and the border is not made up of papular elements.

In syphilis a history of infection can often be obtained, together with evidences, at some time, of lesions upon the mucous membranes and remains of former ulcerations in the form of scars.

*Granuloma Fungoides.*—This disease often develops from erythematous scaly patches indistinguishable from eczema. These spots develop anywhere upon the body, sometimes in the form of erythematous plaques of round or oval form, or in distinctly eczematous scaly patches. They resist every kind of treatment and often last for years, or they may disappear spontaneously only to return again often in the same localities. Patches of eczema showing this life history should be looked upon with suspicion. When infiltration and tumefaction begin the diagnosis of mycosis fungoides is easy.

*Tinea Circinata.*—Ringworm is sometimes confused with eczema, especially when the lesions are numerous. The course of the two diseases, however, is very different. Tinea circinata is an acute eruption, begins usually in a small scaly spot which enlarges rather rapidly, forming a patch with a raised, red, scaly border and a more or less clear center. The patch of squamous eczema enlarges in the same way, but there is no distinct, raised, well-defined border, only a scaly, uniform, slightly infiltrated patch, without tendency to clear in the center. The itching in tinea circinata is slight; in eczema it is always a marked symptom. The former disease runs an acute course; the latter is a chronic form of eruption.

In *eczema marginatum*, or ringworm of the crotch and axilla, there is an eczema with a subjoined infection with the trichophyton fungus. From an ordinary eczema it can be distinguished by its raised, sharply defined, circinate or festooned border and the gradual diminution of the eruption toward the point from which the disease spread.

Whenever there remains any doubt in diagnosis, an examination of the scales by the microscope will reveal the trichophyton spores and mycelia if the eruption is one of ringworm.

*Tinea Versicolor.*—The clinical features of this disease are generally distinctive enough to prevent any mistakes in diagnosis. It occurs in fawn-colored or light brownish spots upon the front or back part of the upper portion of the trunk, and only rarely upon exposed parts, as the face and neck. The patches are covered with fine furfuraceous scales, but there is an entire absence of infiltration and inflammatory symptoms. The itching is slight or absent, the patient often being unaware of the presence of the eruption until attention is called to it. All of the foregoing features would distinguish this disease from eczema. Microscopic examination of the scales will always reveal the characteristic fungus which is the cause of the trouble.

*Herpes.*—It is necessary to differentiate herpes from vesicular eczema, although usually it is not difficult. Simple herpes, or *herpes febrilis*, either of the face or of the genitals, is an acute affection consisting of a group of vesicles which are generally larger than those of eczema. The vesicles in herpes dry up in a few days without discharging and forming a weeping patch as in eczema. Vesicular eczema appears generally in several localities, and does not consist of one or two patches in close proximity as in herpes. *Herpes zoster* generally develops in the course of a nerve or its branches, is preceded by neuralgic pains, and is made up of groups of larger vesicles or even bullæ seated on an erythematous patch; it is also unilateral. Eczema vesiculosa occurs in a disseminated manner, is not associated with neuralgia, and the vesicles are smaller and more closely set. As in herpes simplex, the vesicles in zoster dry up without discharge. Scars are often left after herpes zoster, while scarring is never seen in eczema.

*Dermatitis Herpetiformis.*—The mistake is very

commonly made of diagnosing this disease eczema. In the papular and vesicular varieties of dermatitis herpetiformis the eruption is very much like that of eczema. The disease, however, belongs to the herpetic group of eruptions, and by keeping in mind this fact little difficulty need be experienced.

The lesions of dermatitis herpetiformis develop in crops of grouped papules, vesicles, pustules, or bullæ, accompanied by more or less erythema. These lesions often dry into scaly, red patches, which, after remaining a short time, disappear spontaneously, only to be replaced from time to time by new crops. Eczema rarely behaves in this way, though certain forms of neurotic eczema present much the same picture. There is always rupture and discharge of the lesions, however, in eczema, while in dermatitis herpetiformis they dry up as in other herpetic eruptions without discharging. Dermatitis herpetiformis runs a very long course, lasting often for years with periods of comparative freedom, but ultimate cure in any case is not to be expected. Eczema may last a long time and become chronic, but there is never the history of repeated recurrences covering many years of one's life, as occurs in dermatitis herpetiformis. Eczema is, furthermore, a curable disease. The itching in dermatitis herpetiformis is productive of more suffering than in almost any other known dermatosis. The itching of eczema is bearable as a rule, and can be modified by treatment, whereas in this disease it is only a little or not at all relieved by therapeutic measures.

*Dermatitis.*—The clinical symptoms of dermatitis and eczema are about the same and are often indistinguishable. The history and course, however, are entirely different in the two affections. A dermatitis is an acute eruption, wholly of artificial origin, produced by some irritant coming in contact with the skin. It remains confined to the region irritated, and generally disappears quickly when the source of irritation is removed. Eczema excited by local means spreads beyond the area first subjected to the irritant, even though the cause is removed, and may develop in remote regions, becoming more or less chronic.

In poison-ivy dermatitis the eruption commonly appears in remote parts by autoinfection; active treatment is always needed to destroy the effects of the poison. Its acute character, however, and the history of contact with the plant, will generally distinguish it from eczema.

Eczema of constitutional origin is rarely confounded with dermatitis, for its nature is soon revealed by the history and subsequent course of the eruption.

*Pemphigus.*—Bullous eczema, especially as it occurs in elderly people, may resemble pemphigus vulgaris. The bullæ in pemphigus develop suddenly and without apparent cause from a perfectly normal-looking skin, no redness nor even an areola being seen. Lesions also, sooner or later, develop in the mouth and on other mucous membranes in pemphigus, a circumstance never observed in eczema. Eczema bullosa is always associated with inflammatory symptoms and the bullæ rupture and produce a weeping patch. When the bullæ in pemphigus break, a painful non-exuding bright red area remains. Pemphigus is generally preceded by constitutional disturbances and is a grave disease, the patients often dying in either the first or the second attack.

*Pemphigus foliaceus*, a more generalized form of the disease, spreads rapidly over the body surface, with the production of large flaccid bullæ, which dry into large thin flakes or are rubbed off, leaving raw areas of variable extent without infiltration. Flaccid blebs are never seen in eczema, there is always infiltration, and the disease rarely becomes universal as in pemphigus foliaceus. Moreover, the latter disease goes on to a fatal termination, while eczema never imperils life. Itching is generally absent or slight in both forms of pemphigus, which would distinguish them from eczema. The same mucous membrane lesions also occur in this disease that are seen in pemphigus vulgaris.

*Pityriasis Rubra.*—This is another rare and fatal disease, which in its early stages bears a resemblance to eczema. It begins with redness and scaling, as in squamous eczema, but soon becomes generalized and universal. Large, thin epidermic flakes are continually exfoliated, leaving a bright red moist surface, but there is no infiltration nor weeping as in eczema. Eczema rubrum and eczema squamosum, on the contrary, have a more localized distribution and exhibit the exudation, infiltration, and crusts which are characteristic of the eczematous process. There is likewise no itching in pityriasis rubra, which would distinguish it from eczema. The disease, when once begun, continues without abatement until it eventually destroys the life of the patient.

*Impetigo Contagiosa.*—This is an acute affection of short duration, occurring most commonly upon the face and hands, though in some cases it may extend over the body. The lesions begin as vesicles or small blebs, which speedily become pustules; these rupture and dry into dark crusts. The whole process is superficial, the lesions, generally few in number and scattered, springing from an uninfiltrated base. In pustular eczema the lesions are small and more numerous, are not so isolated, and develop from an infiltrated base, drying into thin scales, from beneath which pus can be expressed.

In impetigo contagiosa there is often a history of the same eruption in other members of the family, or evidence, if in an adult male, of direct infection from a barber shop.

*Pediculosis.*—Pediculosis corporis is often mistaken for eczema. The lesions seen in this affection, however, occur particularly about the back and chest, around the neck and shoulders, and about the waist and over the buttocks. Eczema is rarely limited to these regions. In pediculosis the intensity of the itching and the great number of scratch marks are out of all proportion to the lesions present. There are never any patches as in eczema, but only scratch marks and torn papules capped with a blood crust.

Care in examination of the clothing and even of the skin itself will often reveal the parasites or their nits.

*Pediculi capitis* are a frequent cause of pustular eczema of the scalp, especially in children. In every pustular eczema, whether in children or in adults, this factor must be first eliminated. Either the parasites themselves or their nits can always be detected, and in children enlargement of the posterior cervical glands is almost a sure sign of pediculosis.

*Pediculi pubis* may cause an eczema about the genitals, in the axillæ, or on the edge of the eyelids. With a hand-glass the crab-louse can generally be detected firmly attached to the skin at the base of a hair, or its nits are found on the shaft of the hair.

*Scabies.*—It is very important to differentiate scabies from eczema, since the treatment for one is inappropriate to the other. The lesions of the two diseases resemble each other in a marked degree, and in some cases a distinction cannot be made; in fact, eczema is sometimes caused by the acarus scabiei. In the early stages of scabies, careful search will usually reveal the furrows produced by the burrowing of the female acarus, but in older cases these are masked by the irritation and changes in the skin produced by scratching. The distribution of the eruption in scabies is the chief feature upon which the diagnostician must rely. The regions commonly affected are the interdigital spaces and adjacent surfaces of the fingers, the flexors of the wrists, the elbows, axillæ, buttocks, and thighs. In females the mammæ and nipples are favorite sites, and in males the glans and body of the penis. In children pustular lesions upon the hands, feet, and buttocks are almost

sure to denote scabies. The face and scalp are never invaded by this disease. Eczema may also occur in all these localities, but the lesions are not so scattered, often form patches, which are not seen in scabies except in very aggravated and long-standing cases, and extend to the face, scalp, and other regions not affected in scabies. There is, finally, often a history of infection from fellow-workmen, room-mate, or other members of the family.

*Sycosis.*—For the diagnosis between eczema and sycosis the reader is referred to eczema of the beard.

*Tinea Favosa.*—See Eczema of the scalp (page 841).

*Seborrhea.*—See *Dermatitis Seborrhoica.*

Prognosis.—The question as to the curability of eczema can undoubtedly be answered in the affirmative. It is quite another thing to be able to say when a given attack will be cured or whether the patient is liable to suffer a relapse.

To answer these questions correctly it is necessary for the physician to be familiar with the disease in its varied and manifold phases. He must know his patient as well as the various possibilities and vagaries of the disease itself. Eczema at the best is a very rebellious affection, and one must be guarded against giving a prognosis without carefully weighing the case in all its bearings. Experience, then, must be the physician's chief reliance, as little more than hints or generalizations can be acquired from others.

If the cause of the disease in any given case is known and removable, the chances of a quick recovery are generally good. If the cause has been long in operation, however, it must not be forgotten that the eruption may continue and prove rebellious after this is removed.

Eczema in children and infants, being due generally to known and removable causes, is less rebellious than some other forms and a favorable prognosis can be given. The great tendency to exacerbations in the case of infants, dependent upon irritation of the gastrointestinal tract through teething and other causes, should, however, be borne in mind.

In acute vesicular types of eczema, a speedy and permanent recovery can usually be expected. The forms of eczema requiring more guarded prognoses are the chronic papular, the neurotic and gouty forms, those in elderly people, and certain obstinate types dependent upon locality. Chronic eczema of the scalp is extremely rebellious, as is also chronic squamous eczema of the palms. Eczema of the anus and scrotum, and the form of the eruption which is seen on the lower legs, and which is dependent upon varicose veins, are extremely difficult to cure. Relapses are generally to be expected in gouty, neurotic, and debilitated subjects. In regard to contagion and the likelihood of transmitting the disease by heredity, a negative answer can assuredly be given.

Treatment.—From what has been said thus far, it may readily be inferred that the subject of the treatment of eczema is of vital importance. There is no subject in dermatology of so much consequence to the practitioner, for eczema constitutes a large majority of all the cases of skin disease that come under his care. Unfortunately, however, it is one of the most difficult diseases to treat and often proves most obstinate and rebellious even in the hands of the expert.

In any given case it is necessary at first to discover if possible the cause, and if this is a local one and can be eliminated the simplest local measures will often suffice. But, as already seen, the disease is rarely due to local causes alone, and in order to subserve the best interests of the patient as regards relapses and future attacks, it is necessary to take into consideration every possible factor that may have a bearing upon the case. Every deviation from health should be carefully looked into and all irritating and depressing influences removed as far as possible. Family tendencies, individual idiosyncrasies, temperament, habit, environment, etc., must all be duly weighed if the best results are to be attained. It is the physician with the best knowledge of disease in general who will meet with the greatest success in the treatment and management of eczema. There is no specific for the disease, and every case must be treated on its individual merits. Eczema is curable in almost every instance, and the removal of the eruption is never prejudicial to the patient, but on the contrary is always of great benefit to him. The old theory of *scattering the poison* to internal organs or of *driving it in* is no longer tenable in the light of modern pathology and general medical research.

The remedies and measures employed in the treatment of eczema relate to those having a constitutional effect and those used locally.

*Constitutional Treatment.*—This comprises dietetic, hygienic, and medicinal measures, which if judiciously employed will always be found of great service. It will be necessary only to indicate in a brief way the dietary and other measures that have, by experience, proved the most useful in this disease, leaving much to the good judgment of the physician.

*Diet and Hygiene.*—There is no fixed diet that will apply to all cases of eczema, as it will necessarily vary according to the requirements of each individual case. If it were possible to generalize at all, I think a non-nitrogenous, easily assimilated diet would be suited to the greatest number of cases. In infants and children the regulation of the diet is perhaps the most important part of the treatment, for in these subjects it is most often grievously at fault. The nursling should be limited to milk or, if the breast milk is insufficient, to cow's milk properly modified, and not allowed to have a taste of everything on the parents' table, including tea, coffee, beer, and all kinds of solid food. This practice is unfortunately very common among children of the poor, and it is needless to say that eczema flourishes under such conditions. Older children and those in the better walks of life are often allowed confectionery, rich cakes, pastry, soda water, and all kinds of indigestible things. All these should be strictly prohibited if good results in the management of the eczema are to be expected. There is one article of food which, I think, is responsible for more trouble in the eczema of infants and children than any other one thing; I refer to bananas. Bananas are nutritious, easily accessible, and convenient, for which reasons they are consumed in large quantities. However well they may be digested and assimilated by some healthy subjects, I feel certain they are extremely harmful in those suffering from eczema. This applies to adults as well as to children —a fact which I have been able to demonstrate to patients time and again. In acute eczema it is well to restrict the diet to one of milk, bread and butter, eggs, chicken, fish, and vegetables, with possibly meat, such as beef, lamb, and mutton two or three times a week. A purely vegetable diet, with milk and cereals, is often advisable in this form of the disease. All salt and highly seasoned meats, as pork, corned beef, ham, and sausages, together with richly fried and made dishes, rich gravies, condiments, pastry, cheese, pickles, nuts, olives, etc., should be forbidden. Such a restricted diet is likewise appropriate to the gouty subject, who should avoid, in addition, excess of starches and sweets. These patients should also use freely some good diuretic water, such as Poland, Bethesda, or Lithia water, taking it preferably before eating. In the plethoric a diet of milk and vegetables, or at least a non-albuminous regimen devoid of stimulating or heating articles, is very essential.

When there is an impairment of the digestive functions, as evidenced by dyspepsia in one form or another, a diet must be selected appropriate to the condition present. Eczema patients often suffer from fermentation and acidity, and complain much of flushing after eating. The avoidance of sweets,

starches, pancakes, fritters, crullers, and the numerous class of articles that are difficult of digestion is to be advised in these cases. Strawberries, shell fish, and any article of diet that is known to cause eruptions of any kind should be avoided by those suffering from eczema.

In old people and in those debilitated from any cause, a nutritious supporting dietary is necessary. This is particularly true in those reduced from nervous strain, anxiety, or overwork, and in patients of a strumous or lymphatic habit. A diet of milk, rich cream, eggs, butter, and easily assimilated foods, as chicken, fish, fresh vegetables, graham bread, and wheat cereals, is most desirable in these cases. Milk, slightly warmed, given without any other food an hour before eating and continued for indefinite periods, is most efficacious in neurotic and debilitated subjects. In all varieties of eczema alcohol in every form should be avoided, including even the lighter wines, champagne, beer, ale, and porter. In elderly debilitated patients and in those accustomed to its use, a small allowance may sometimes be advantageously given. Tobacco in any form aggravates eczema, especially eczema of the anus, and in those having weak digestions it should never be used. Tea, coffee, and chocolate should be taken only sparingly by eczema patients.

Fresh air, both in the dwelling and out of doors, together with a moderate amount of exercise, as walking, rowing, golfing, bicycling, or gymnastic exercises, is all-important in connection with the treatment of many cases of eczema.

The clothing worn by these patients is a very important consideration. Woollen should never be worn next to the skin, underwear of muslin, silk, or linen mesh being best suited to this condition. For warmth, woollen may be worn over these if necessary, but this matter is better regulated by changes in the outer garments. The heavy bundling up that infants are often subjected to is to be deprecated. This applies particularly to the babies of the poor, who are often wrapped in yards of heavy coarse flannel, which is not only a great hardship to the child, but is productive of much harm.

The subject of bathing deserves special mention, for upon proper judgment in this respect much may depend. Indiscriminate bathing is undoubtedly harmful, and Turkish and Russian vapor baths as a rule should be discouraged. The daily bathing of the sound skin, followed by mild friction, is, however, desirable and indeed necessary in many cases; but if a large part of the body surface is affected the daily bath must be omitted. In these cases alkaline baths two or three times a week are very serviceable. One of the most useful formulæ for a bath powder is the following: ℞ Potass. carbonat., ℥ iv.; sod. carbonat., ℥ iij.; sod. biborat., ℥ ij. M. This should be used in a thirty-gallon bath, together with a pound or two of ordinary laundry starch. Sulphuret of potassium may be used in the strength of from ℥ ij. to ℥ iv. to thirty gallons in similar cases. Glycerin, from ℥ iij. to ℥ vi. to thirty gallons, is also a useful form of medication. The first inclination in most patients is to wash the part affected with eczema, not alone for the purpose of keeping it clean, but because much relief is temporarily experienced thereby. This practice, however, interferes most seriously with repair, and must be strenuously prohibited in all cases. I have found that bathing the part with warm milk is soothing and advantageous; this is especially applicable to infants and children. The value of treatment at various mineral springs, where patients bathe and drink of the waters, is in my opinion questionable. A certain few may receive benefit, but I believe that the importance sometimes attributed to them in the treatment of eczema is greatly exaggerated.

*Drugs.*—The indications for the administration of medicines in eczema are generally to be looked for in the patients themselves and not in the disease. While it is very essential to appreciate the effects of remedies in the various stages of the eruption in order to select those most suited to the condition, it is nevertheless too true that undue attention is often given to the skin itself and too little regard paid to the individual.

The truth of this statement is nowhere more apparent than is seen in connection with the single symptom of pruritus. From the very beginning of an attack of eczema the first and chief concern of the patient is to get relief from this distressing symptom. The physician, in his efforts to accomplish this, is often led to resort to sedatives of one form or another, such as opium, chloral, bromides, phenacetin, sulphonal, trional, etc. The ultimate result is an aggravation of the eczema, and hence an increase in the itching, the very symptom for the relief of which they were given. It may safely be put down as an axiom that *eczema will cease to itch when it is cured, and not until then.* It is therefore both useless and harmful to use antipruritic drugs, but instead every effort should be made to cure the disease as quickly as possible.

As already mentioned, disorders of the gastrointestinal tract are most commonly met with in connection with eczema, and these should receive the physician's first attention.

Constipation may be relieved by small and continuous doses of fluid extract of cascara sagrada or by the well-known pill of aloin, belladonna, and strychnine, given at bedtime. I have found a pill containing gr. i. aloin, gr. i. extract cascara, and gr. ½ extract nux vomica of very great service in this connection. Calomel in small doses, gr. $\frac{1}{10}$ to gr. ½ three or four times a day for several days in succession, with a mild saline before breakfast, such as a teaspoonful or two of equal parts of sulphate and phosphate of soda in half a glass of water, will often prove effective. The pill of aloes and iron of the Pharmacopeia is likewise an excellent remedy, given about three times a day. Saline aperients, as Rochelle, Glauber's, or Carlsbad salts, and the laxative mineral waters Hunyadi János, Rubinat, etc., are useful in some cases. Care must be taken, however, not to use these too continuously, except in plethoric subjects and in those with much liver torpor. In many cases it is advisable to begin by a rather smart purge, as a five-grain blue pill for a few nights, followed by a seidlitz powder or citrate of magnesia the next morning. A pill of blue mass, colocynth, and ipecac, containing gr. iiss. each of blue mass and compound extract of colocynth and gr. ss. of powdered ipecac, given two at bedtime, and repeated the second night following, is particularly serviceable. I have also gotten most excellent results from the following: ℞ Leptandrin, gr. viij.; podophyllin, gr. ij.; ipecac, gr. v.; ext. hyoscyami, ℥ss.; ext. belladonnæ, gr. ij.; ext. aloes, ℥ss. M. ft. in pil. No. xxx. Sig. Two every second night for three times. It is generally advantageous to repeat these bilious pills at intervals of two or three weeks. For more or less continuous use a pill containing gr. i. calomel and gr. ⅛ to gr. ½ podophyllin has proved very useful in my hands; this pill may be given once or twice a day, preferably at night.

For the treatment of constipation and stomach derangements in infants, the reader is referred to Infantile Eczema (p. 840).

In dyspeptic conditions, besides the dietary regulations already referred to, the following therapeutic agencies will be found of service. In the flatulent and atonic forms, alkalies and bitters are required, as also the dilute mineral acids. I have found that gtt. x. to xv. of dilute nitrohydrochloric acid, given well diluted before eating, relieves the flatulency and consequent flushing so often complained of. Strychnine or nux vomica is likewise effective in this condition. Bismuth, liquor potassæ, magnesia, and bicarbonate of soda are useful in cases of acidity, and much good is

often derived in similar cases from a mixture of rhubarb and soda. A good formula is: ℞ Pulv. rhei, ʒss.; sod. bicarb., ʒij.; pulv. ipec., gr. x.; aq. menth. pip., ad ʒiij. M. Sig. Teaspoonful well diluted before eating.

Gouty subjects require alkalies, as citrate and acetate of potassium in doses of from ten to twenty grains three times a day. These may be given separately or combined, and generally a little iron taken with them increases their effectiveness.

The alkaline diuretics, benzoate of soda or lithia, and the free use of Poland, Lithia, or natural Vichy waters, can be prescribed with benefit to these patients. Salicin and colchicum may be given in some of the more chronic cases, but their efficacy in most instances is somewhat doubtful. It is never advisable to continue these remedies for long periods of time, but they should be occasionally interrupted and general tonics of iron, quinine, cinchona, etc., substituted.

In the strumous and debilitated, supporting tonic treatment is needed, such as cod-liver oil, quinine, hypophosphites, syrup of iodide of iron, the glycerophosphates, etc.

In all cases of acute eczema salines and gentle aperient mixtures are indicated at first, to be followed later by more tonic remedies. One of the most useful mixtures in the acute stage of the disease is that known as Startin's mixture, which is made as follows: ℞ Magnes. sulphat., ʒiv.; ferri sulphat. exsiccat., ʒi.; acidi sulphur. dil., ʒiij.; syrup zingiberis, ʒvi.; aquæ, ad ʒiij. M. Sig. Teaspoonful in water after meals through a tube. In cases in which there is anemia, chlorosis, malaria, or other general disease, the usual treatment employed in those conditions should be instituted. The preparations of iron best suited to the treatment of eczema are reduced and dialyzed iron, the citrate of iron and ammonia, and the citrate of iron and quinine.

Warburg's tincture, with or without aloes, is often a very valuable remedy, and ergot in selected cases may be given with benefit.

Arsenic is useful in a very limited number of cases, and should only exceptionally be resorted to. Its indiscriminate employment cannot be too severely condemned, for it is a dangerous remedy and is often productive of much harm. It is probably used less by those especially conversant with cutaneous medicine than any one remedy or class of remedies. It should never be given in acute cases, nor to patients in whom the digestion is weak or imperfect. In chronic and inveterate cases of the squamous and infiltrated types it is sometimes serviceable, but even in these it is better not to resort to it until all other remedies have proved ineffectual. It is chiefly of value in those cases of neurotic eczema in adults, in which the eruption develops in crops from time to time, and is most rebellious to treatment of any kind. It is also practically the only remedy that will control the bullous form of the disease which occurs in elderly people. The preparations generally employed are arsenous acid, Fowler's solution, liquor sodii arsenitis, and arsenous acid combined with black pepper in the so-called "*Asiatic pill.*" I think the best results are obtained with the soda salt, for although it is weaker than the potassium salt it is better borne by the stomach and can be continued for a longer period. It is best given in small, frequently repeated doses, beginning with one or two minims, increased slowly to six or more minims every two hours. Fowler's solution may be given in the same manner, but in smaller doses. The usual dose of arsenous acid is from gr. $\frac{1}{50}$ to gr. $\frac{1}{30}$ three or four times a day. From three to six of the Asiatic pills, each containing gr. $\frac{1}{30}$ arsenous acid and gr. ij. to iv. of pepper, may be given during the twenty-four hours. In the administration of arsenic it is necessary to push it to the point of tolerance to produce the desired effect. It is always advisable to examine the urine at frequent intervals during the administration of this remedy, and upon the first evidence of abnormal kidney action it should be discontinued.

*Local Treatment.*—Success in the treatment of eczema will depend largely upon the proper selection and application of the various remedies and measures employed locally. There is no case that does not require local treatment in one form or another. If an opposite effect than the one expected is produced by any given application or procedure, no one will be more quickly aware of this fact than the patient himself. It is essential, therefore, to the interests of the patient, and often for the sake of his own reputation, that the physician should have this part of the subject well in hand. It is not necessary nor even advantageous to know all the newer remedies and complex formulæ that are continually being advocated. What is needed is a knowledge of the general principles governing the use of the more common remedies and a familiarity with the drugs themselves and the effect they have upon diseased skin. In the treatment of skin diseases, as in every other branch of medicine, the simplest procedures are often the most successful, but the important question is when to apply them and how to apply them. A remedy may be used by one physician with the very best effect, while the same in the hands of another, used in precisely the same condition, will prove most disastrous. This is generally dependent upon the form in which the remedy is used, whether as a lotion, ointment, paint, etc., or upon the manner in which it is applied.

*Selection of Remedies and Methods of Treatment.*—In choosing the remedies the physician should be governed by the character and intensity of the inflammation, the locality and extent of surface affected, and the secondary changes that have taken place. It is also often necessary to consider the occupation, habits, and social position of the individual, in order to suit the treatment as much as possible to his convenience.

It is always a good rule to employ the very mildest treatment possible when the patient first comes under observation, the remedies being strengthened from time to time. The mistake is often made of employing too strong remedies at first, which not only proves disastrous, but destroys the confidence of the patient at the beginning. In a general way it may be said that lotions—particularly those carrying powders in suspension—agree with most skins better than ointments. Upon discharging surfaces they are as a rule much more satisfactory than dusting powders, for the latter cake and subsequently irritate. If the surface affected is very large, it is obvious that to use a lotion over the whole would not be feasible, and it is then necessary to soak strips of linen or gauze in liniments which can be laid on or wrapped about the part. Ordinarily lotions are sopped on by means of a piece of old linen or gauze; it is seldom necessary to rub them in.

In using ointments much depends upon the method of application. In acute cases in which a soothing effect is desired, it is essential that the ointment be spread upon surgical lint and bound on in the manner of a plaster. It is useless in such cases to rub it on with the fingers. In chronic cases requiring stimulation, strong salves may be advantageously rubbed in and then bound on.

In certain rare instances neither lotions nor salves will be well borne and other forms of application, such as powders, pastes, plasters, gelatins, soaps, paints, etc., must be employed.

Other methods which may be classed as mechanical, such as counterirritation, circumcision, use of rubber bandage, scarifying, hot water, alkaline baths, etc., are referred to in their proper places.

*Measures to be Employed in Acute and Subacute Eczema.*—The first thing to do is to remove crusts if

present. This is best accomplished by laying on strips of linen soaked in olive or almond oil; by soaking with a three to five per cent. salicylic oil; or by the use of alkaline emulsions of bicarbonate of soda, borax, etc. When the surface is cleansed, the proper remedy should then be applied, great care being observed not to employ it too strong.

For freely discharging surfaces *dusting powders*, generously employed, are of greatest service. Those most commonly used are plain corn starch, rice powder, chalk, talc, kaolin, lycopodium, and magnesium carbonate. The stearate of zinc with salicylic acid or salol and the oleates of zinc or bismuth have the advantage of caking less with the secretions than do some of the other powders.

It is often advantageous to add to the simple powders equal parts of oxide of zinc or one part of bismuth subnitrate, boric acid, or camphor to four of the powder. In the same manner salicylic acid, salol, or acetanilid in strength of from twenty to thirty grains to the ounce may be useful additions in some cases. After the excessive weeping has been arrested by the use of dusting powders, it will be found most convenient to use some drying, slightly astringent lotion. *Lotions* are very cooling and grateful to the patient, and are to be preferred in most cases of acute vesicular or erythematous eczema. One of the most useful in acute vesicular eczema is composed of a dram each of carbonate of magnesia and oxide of zinc in four ounces of water. Boric acid in three or four per cent. strength may be added to this lotion when needed, and if the itching is excessive, one per cent. of carbolic acid may likewise be added. Duhring and White employ in the acute oozing stage lotio nigra, either in full strength or diluted one-half with lime water, and they report very favorable results from its use. The eruption is bathed with it for fifteen or twenty minutes, the sediment is then allowed to dry on and a plaster of oxide of zinc ointment is immediately bound on. The applications of the lotion are made every ten or twelve hours. In acute erythematous eczema there is no application so useful as the following lotion of calamine and zinc: ℞ Acid. carbol., ʒ ss.; pulv. calamini prep., ʒ i.; zinci oxidi, ʒ ij.; glycerini, ʒ iij.; aq. calcis, ʒ iv.; aq. rosæ, ad ʒ iv. This should be dabbed on two or three times a day and the sediment allowed to remain on. It is a most cooling and soothing application. In some cases I have found it advantageous to substitute lotio nigra for the lime-water in this lotion. It must be remembered that some skins do not tolerate either glycerin or carbolic acid; in such cases almond oil may be substituted for the former and dilute hydrocyanic acid for the latter.

Another useful lotion in papular vesicular eczema contains boric acid two and one-half per cent., zinc oxide and bismuth oxychloride each four per cent., in cherry-laurel water.

In acute papular eczema of the dry, itchy type, a cooling lotion recommended by Cæsar Boeck of Christiania is particularly serviceable. This consists of powdered starch and talc each 100 parts, glycerin 40 parts, lead water 200 parts. It should be used first diluted with two parts of water. In this same type of eruption the magnesia and zinc lotion just referred to, with the addition of three to six per cent. of ichthyol, will be found very useful.

When there is an extensive oozing surface *liniments* prove more serviceable than either powders or lotions. The parts should be enveloped in cloths soaked with the liniment, and these should be changed about twice a day. In this way excessive drying and subsequent irritation and injury are prevented. Linseed, almond, or olive oil may be used combined with glycerin, lime-water, dilute alcohol, etc. Equal parts of linseed oil and lime-water (carron oil) will be found very useful in this connection.

*Ointments* may often be employed with great benefit in acute stages of the disease. Great care is necessary, however, not only in the selection of the ingredients, but also as regards the manner in which they are incorporated. Much harm may be done by the use of a salve made with a rancid ointment base or one made with a base naturally irritating to an inflamed skin. Vaseline or cosmoline, except in special instances, should not be used as a base for ointments employed in acute stages of the disease. Benzoated lard has the disadvantage of becoming easily rancid, and lanolin has too much body, but if mixed in the proportion of about one to four with some soft emollient, the latter makes a good ointment base. Freshly made cold cream or rose-water ointment makes the best base for salves; it is soothing and the evaporation of the rose water it contains produces a cooling effect. Duhring gives a good formula for making cold cream, which consists of rose water and oil of sweet almond, ten parts each; white wax and spermaceti, two parts each; these to be emulsified with sodium biborate, one-half of one per cent.

Much likewise depends upon the way an ointment is made. If it is not perfectly smooth, but contains gritty particles, it is sure to irritate, no matter how fresh or mild the ingredients may be. Some substances, such as tannic acid, resorcin, etc., occur in the form of tiny sharp crystals, and unless these are previously dissolved before being incorporated in the salve, harm will surely follow.

For a simple protective nothing is better than oxide of zinc ointment in the strength of a half dram to the ounce of cold cream. Bismuth subnitrate or oleate of zinc may be used for the same purpose and in the same strength. A very soothing ointment for use in acute eczema is one composed of prepared calamine powder, gr. xx.; zinci oxidi, gr. xxx.; acidi carbolici, gr. v.; ungt. aquæ rosæ, ʒi. Instead of the carbolic acid a half dram of tincture of camphor may prove of more benefit in some cases. Salicylic acid in mild strength is a most useful remedy in acute and subacute eczema. Used in the strength of two per cent. in the zinc ointment already referred to, it rarely fails to do good. In the form of a paste, first recommended by Lassar, it is an extremely efficacious remedy. The formula is as follows: ℞ Pulv. acidi salicylici, gr. x.; zinci oxidi, pulv. amyli, āā ʒij.; vaselini, ʒj. In acute eczema, especially of the face and scalp and in eczema of the toes, a tannin ointment composed as follows is very effective: ℞ Acid. carbol., gr. v.; pulv. acidi tannici, tannin. glycerit., āā ʒss.; ungt. aq. rosæ, ʒi. A useful ointment in acute erythematous eczema is one composed of four per cent. boric acid and two per cent. salicylic acid in equal parts of lanolin and rose-water ointment.

Hebra's diachylon ointment, used alone or with the addition of one per cent. of salicylic acid, or mixed with equal parts of zinc ointment, is very valuable in acute and subacute eczema. Its ingredients are: ℞ Olei olivæ opt., ʒxv.; lithargyri, ʒiij + ʒvi.; aquæ q. s., to which is added olei lavandulæ, ʒ iij. The oil is mixed with a pint of water, heated to boiling; then the finely powdered litharge is stirred in until it cools.

In certain cases *pastes* composed of tragacanth, gelatin, etc., are tolerated better than salves. Unna's gelatin paste or *"Zinc-Leim"* is composed of gelatin. alba, ʒvi.; glycerini, ʒix.; aquæ, ʒij.; zinc. oxid., ʒvi. The gelatin is melted in the water with heat, then the glycerin and zinc are added. A hard jelly results upon cooling, which requires liquefying in a water-bath before it is applied. This is then painted on with a brush, and while it is drying, fibers of absorbent cotton are made to adhere to the surface. It may be washed off or stripped off *en masse*, and is a cleanly and effective dressing.

*Gelanthum*, one of the best ointment bases, consists of gelatin and tragacanth each two and one-half per cent. and glycerin five per cent. in water. Any

medicament can be incorporated with it. It is simply necessary to paint it on with the finger when it quickly dries, leaving a coating upon the skin; it can be readily removed with a little water.

The *salve muslins* devised by Unna are very useful methods of making applications to the skin, but as they are imported it is not always possible to get them fresh. On this account they are not to be recommended for general use.

*Measures to be Employed in Chronic Eczema.*—In the local treatment of chronic eczema various remedies and methods are employed, among the most useful of which are the different preparations of mercury and tar. These may be used in the form of either lotions or salves and may often be combined with advantage. The mercurials of special value are ammoniated mercury and calomel used in strengths varying from two to ten per cent.; the yellow oxide and red oxide in two or three per cent. strength; the nitrate and oleate in two to five per cent. strength; and in certain cases the bichloride and red sulphide. Sometimes the mercurials are advantageously combined with sulphur. A most useful formula for chronic indolent patches consists of ℞ Ungt. hyd. oxidi rubri, ʒiss.; ungt. sulphuris, ʒiij.; ungt. zinc. oxid., ad ʒi. M. In chronic impetiginous eczema the following white precipitate ointment is particularly effective: ℞ Acidi carbol., gr. v.; bismuth subnitrat., ʒss.; ungt. hydrarg. ammoniat., ʒij.; ungt. aq. rosæ, ad ʒi. M. In a similar condition, especially when located upon the scalp, the following combination will be found useful: ℞ Hyd. ammoniat., gr. xxv.; calomel, gr. xx.; acid. salicylici, gr. xv.; ungt. hydrarg. nitrat., ʒiij.; ungt. aq. rosæ, ad ʒi. M. Among the tars most commonly employed may be mentioned: Pix liquida, oleum cadinum, oleum rusci (crude), ichthyol, and thiol. A very effective tar ointment is that known as Ungt. picis et zinci and is made as follows: ℞ Ungt. picis liquid., ʒij.; zinci oxidi, ʒss.; ungt. aq. ros., ad ʒi. M. This may be used alone or combined with equal parts of Hebra's diachylon ointment. It is a most effective antipruritic and is very serviceable in chronic infiltrated patches and in eczema of the anus and scrotum. Oil of cade and oleum rusci may be used pure, in which case they are painted on to chronic scaly patches, or they may be used in solution in alcohol in strength of two parts of the tar to one of alcohol. In ointments they are generally employed in strength of ʒss. to ʒi. to the ounce. Ichthyol and thiol may be used in the same manner. The latter has less odor than ichthyol, but in my experience it is less effective. They may be used in watery solution, five to ten per cent. or stronger, or they may be employed in ointment in strengths varying from three to fifty per cent.

In the treatment of infiltrated localized chronic patches, a solution known as *"liquor picis alkalinus"* is most valuable. Its formula is, ℞ Picis liquidæ, ʒij.; potass. causticæ, ʒi.; aquæ, ʒv. M. Dissolve the potassa in the water and add the tar with rubbing in a mortar. It is generally used diluted five to ten times with water, and after rubbing the patches once or twice a day with it a soothing ointment is applied. It may also be employed as an antipruritic lotion in less chronic conditions in strength of from one to three drams to the pint of water or in an ointment in strength of ten to twenty minims to the ounce. For chronic localized patches the following ointment will also be found of great service: ℞ Picis liquid., ʒij.; plumbi glycerol., ʒiij.; ungt. diachyli (Hebra), lanolin., āā ʒss. M.

In addition to the remedies already mentioned some other drugs, such as resorcin, chrysarobin, pyrogallic and salicylic acids, rhubarb, beta-naphthol, iatrol, permanganate of potassium, etc., may serve a useful purpose in the treatment of chronic eczema. Resorcin may be used in a lotion or ointment in strength of from two to six per cent. Chrysarobin, pyrogallic and salicylic acids are often conveniently dissolved in liquid gutta-percha or collodion and used as a paint which may be applied once or twice a day. They may be used in strength of from three to ten per cent. Powdered rhubarb in four or five per cent. strength in an ointment is useful in chronic parasitic types of the disease. A four-per-cent. ointment of rhubarb combined with equal parts of ungt. picis et zinci, is likewise of great service. Beta-naphthol and iatrol are generally used in about three-per-cent. strength, while permanganate of potassium in one or two per cent. watery solution is useful as a paint.

The following combinations will be found of service in chronic squamous types of the disease: ℞ Magnes. carbonat., zinci oxidi, āā ʒi.; sod. salicylat., ʒiss.; iatrol, gr. l.; aquæ, ad ʒiv. M.; and ℞ Acid. salicylici, gr. xv.; Acid. pyrogallici, gr. xxv.; spts. vini rectificat., ʒi. M.; also ℞ Ichthyol, gtt. xx.; resorcini, gr. x.; aquæ, ʒi. M.

It only remains to refer to the use of medicated soaps, soap plasters, caustics, and counterirritants in the treatment of chronic eczema. Almost every remedy employed in the treatment of eczema has been incorporated into a soap, so that we have ichthyol, salicylic, naphthol, bichloride, tar, and innumerable other kinds of medicated soaps. Personally I have had but little experience in the use of these, but if properly employed, allowing the lather to dry upon the diseased skin, they should be useful in the treatment of eczema.

Various forms of soap plasters have been recently recommended, many of which are certainly serviceable. One of the best is Duhring's modification of Pick's salicylic soap plaster. It is especially indicated in subacute or chronic vesicular or vesicopapular patches, and is composed as follows: ℞ Emplast. saponis (U. S. P.) liquefact., 90.0; ol. olivæ opt., 10.0; acidi salicylici, 2.0. M. It should be spread on muslin or thin kid and applied continuously.

Hebra's soap treatment for chronic indolent patches is extremely effective. It consists in rubbing into the patch a piece of sapo mollis the size of a walnut by means of a piece of white flannel dipped into water. The affected part is thoroughly scrubbed with the lather until all the scales are removed, leaving a bright red, tense, oozing surface. Plasters of oleate of zinc or diachylon ointment are then firmly bandaged on and left until the next application of the soap. This is usually done about twice a day and results in a rapid removal of the diseased patch. Tincture of green soap, two parts green soap to one of alcohol, may be used for the same purpose, or a mixture of equal parts of green soap, oil of cade, and alcohol. The caustics most commonly employed in the same capacity are liquor potassæ and solutions of caustic potash, five to ten grains to the ounce. Crocker has found that in certain cases of inveterate eczema in which relapses are frequent, counterirritation to the spine sometimes proves curative. For the upper half of the body he applies it to the nape of the neck, and, for the lower half, over the lumbar enlargement. Dry heat or a mustard leaf may be applied in this way without fear of exciting an eczema in the neighborhood.

### Regional and Special Varieties of Eczema.

Infantile Eczema.—This is generally understood to include all cases of eczema occurring in children under five years of age, and, according to statistics made by Crocker in London, about one-third of all these begin during the first year of life.

Eczema in babies and young children generally begins somewhere upon the head, usually in the center of the cheeks or behind the ears. First there is a

scaly patch which enlarges slowly and soon develops vesicles and pustules which rupture and dry into more or less thick, blood-stained crusts. As the cases ordinarily come for treatment, they present large crusted patches of eruption on both cheeks, on the forehead, chin, ears, neck, and scalp, and often similar patches of disease upon the extensors of the forearms and wrists. The skin is always affected in a symmetrical manner and in the worst cases the whole head may be uniformly involved, saving a small area around the mouth, nose, and eyes, where the white, healthy skin stands out in striking contrast. The eruption often extends to other parts of the body and limbs, and in older children may become more or less general.

The disease is frequently complicated by furuncles and abscesses situated especially upon the scalp, face, and neck, and in poorly nourished and strumous infants, conjunctivitis, blepharitis, or otorrhea may likewise coexist. In children of the poor, pediculi play an important part in producing and keeping up the trouble.

The posterior cervical lymphatic glands are considerably enlarged in these cases and are a source of great concern to the parents. These rarely break down, however, but disappear slowly when the eruption gets well.

Though eczema may occur in ill-nourished, strumous, and rickety infants, it seems to have been my experience to find it more commonly in well-nourished, fat, and healthy subjects. In a few cases the disease is apparently inherited, in which event it is liable to continue after infancy and often become chronic in adult life.

The delicate skin of the infant is very susceptible to local irritants of one form or another, and no doubt the eczema is due to local causes alone in some cases. The great majority, however, are dependent upon improper or excessive feeding and disorders of the gastrointestinal tract engendered thereby. Dentition is often spoken of as a cause of the trouble, but in most instances the eruption develops long before the teeth are thought of. The disease is always aggravated by teething, but in a reflex manner through the disturbances of digestion which it causes.

In a certain few cases, infantile eczema, in both the male and the female, occurs reflexly from an adherent prepuce and is not cured until this is relieved by circumcision or by stripping.

It is important to differentiate ordinary infantile eczema from syphilis as it occurs in the neighborhood of the mouth and genitals, from impetiginous eczema due to pediculi, and from dermatitis seborrhoica.

In syphilis about the mouth there are radiating fissures from the corners which extend to the mucous membrane, and mucous patches are often present on the lips and over the tongue. The separate papules and mucous tubercles about the anus, genitals, and buttocks of a syphilitic child could not be readily mistaken for eczema. The presence of snuffles and the bad general condition of the child would also usually distinguish syphilis.

A chain of enlarged lymphatic glands in the neck of a child with eczema of the scalp and neighborhood is almost a sure sign of pediculosis. With a little care the parasites or their nits can be readily discovered. The eruption of seborrhoic dermatitis in infants begins upon the scalp as a thick, moist, crusted patch on the vertex, which lacks the acute inflammatory characters of ordinary eczema. It may extend down on to the forehead and involve the region of the ears, but it rarely covers the centers of the cheek symmetrically and never presents thick blood-stained crusts. It likewise occurs around the umbilicus and in the groins. In the latter situation it may be distinguished from eczema intertrigo by its dull-red color, and especially by the fact of its presenting isolated papules beyond the border of the patch. Dermatitis seborrhoica in this region shows more infiltration and inflammation at the periphery than in the crotch, while the reverse is true in eczema intertrigo.

In the *treatment* of infantile eczema it is necessary first to eliminate all possible sources of local irritation. If pediculi are present, the hair should be cut and the head soaked repeatedly in kerosene oil to destroy the parasites and nits. A three to five per cent. white precipitate ointment may be used for the same purpose. After these are removed the eczema is readily cured by the use of a two or three per cent. ichthyol ointment. In eczema intertrigo, it is important to have the diapers changed and washed frequently. The practice of reapplying them after hanging them up to dry is responsible for keeping up the disease in many cases. Dusting powders and cooling lotions are best suited to eczema in this locality. The calamine and zinc lotion or the magnesia and zinc lotion already referred to are of especial value in this type of the disease.

Every attention should be given to the feeding of the baby. If it nurses, constipation in the mother should be corrected and she should not be allowed to drink beer or spirits. If the child is bottle-fed the milk should be suitably modified according to the age and requirements of the patient. Patent foods, as a rule, should be prohibited, unless for some reason it becomes necessary to stop the milk. The other precautions referred to in the section devoted to the subject of diet should likewise be considered. For constipation in the child, castor oil is a very useful remedy; or a mixture of equal parts of castor oil, mistura cretæ, and water may be given twice or three times a day in teaspoonful doses. Calomel and soda, gr. $\frac{1}{10}$–$\frac{1}{2}$ of the former, with gr. iij.–v. of the latter, given in powder every second morning, is an exceedingly effective remedy in infantile eczema. Some patients, especially strumous subjects, do well under the following tonic: ℞ Liq. sodii arsenitis, gtt. ij.; tinct. nucis vom., gtt. x.; syr. ferri iodid., ʒ iss.; syrup. aurant. flor., ʒ iij.; Spts. mindereri, ʒ iss.; aquæ ad ʒ iij. M. Teaspoonful twice a day. In the local treatment every effort should be made to protect the inflamed skin and guard it from injury. The hands of the patient must be done up or encased in mittens to prevent its doing injury with the nails, and sometimes it is even necessary to confine the hands and arms to the sides. An ointment of salicylic acid and zinc, in strength of two per cent. of the former and six per cent. of the latter, smeared on two or three times a day, is often all that is needed. This may be advantageously alternated with the calamine and zinc lotion or with the ointment of calamine, camphor, and zinc already mentioned. When the inflammation has subsided, a mild tar ointment may be employed, or two or three per cent. of ichthyol may be added to the magnesia and zinc lotion. In all cases relapses are frequent and a cure cannot be safely promised until the child reaches two or two and a half years of age.

Parasitic Eczema.—We are in the habit of classifying as parasitic those sharply defined, moist, or crusted patches seen upon the lower legs accompanying varicose veins; the infiltrated, scaly, indolent, sharply defined patches which sometimes weep and become crusted and are situated in the flexors of the elbows and knees, and on the neck; and certain moist circumscribed patches occurring between the fingers, beneath the breasts, in the groins, axillæ, etc. A form of parasitic eczema occurs also in the corners of the mouth, resulting in cracks and a scaly outlying patch, which is extremely obstinate and rebellious under any form of treatment.

No parasite has been demonstrated in these types of the disease, but they are regarded as due to parasitic infection from their general behavior, and because they yield only to strong antiparasitic treatment.

In parasitic eczema in general a paint of permanganate of potassium ʒ ss. to ʒ iij., applied twice daily,

followed by a four-per-cent. ointment of powdered rhubarb with zinc, arrests the progress of the disease very promptly. In the indolent, infiltrated form ten per cent. chrysophanic acid in traumaticin (liquid gutta percha) is very effective when painted on once or twice a day. Five to ten per cent. pyrogallic acid in alcohol, used in the same manner, is likewise most efficacious.

Ichthyol used in a strength of from ten to twenty-five per cent. acts particularly well in that form which affects the corners of the mouth.

Eczema of the Scalp.—Eczema manifests itself in various ways upon the scalp. In children and infants it appears more often as a vesicular or pustular affection, while in adults it is generally of the chronic erythematous or squamous variety. It may be limited to the scalp in both children and adults or may be only a part of a more generalized eruption. The pustular form of the disease as it occurs in infants and the impetiginous crusted eczema of older children, including the form associated with pediculosis, have already been considered. In adults the same clinical picture of pustular eczema is sometimes seen as that observed in children. It begins in the same way, in groups of pustules which generally dry without rupturing, forming patches covered with thick, dirty-looking crusts. These may form anywhere upon the scalp and often coalesce into more extensive areas. The hair is matted down by the drying discharge and presents a most offensive and disgusting condition. This form usually occurs in poorly nourished subjects and in those who are neglectful of their persons. Itching, as a rule, is not complained of in this type of the disease, but sensations of soreness and burning pain are common symptoms.

The erythematous form of the eruption begins as a dry, red, scaly patch of variable size and outline, which grows slowly larger and becomes thickened and infiltrated. It soon runs into a chronic condition and in certain parts of the scalp, such as the hollow below the nucha, may remain for years resisting almost every form of treatment. These patches are very sharply defined, and there is so much infiltration that the diseased area projects above the natural level of the skin. Erythematous eczema may also spread over the scalp in an acute manner, with general redness, edema, and sometimes vesiculation. The itching and burning in these cases are intense during the acute stage. Later, the disease becomes squamous in character and the affected skin is covered with dry furfuraceous scales.

The diseases most often confounded with eczema of the scalp are psoriasis, seborrhoic dermatitis, tinea favosa, and tinea tonsurans.

Psoriasis of the scalp presents about the same characteristics as when it appears upon the body; the patches never show moisture or soft crusts from the drying of a discharge, but are covered with dry micaceous scales or those of a thick imbricated character. The itching in psoriasis is not so severe as in eczema, and some evidence of the disease elsewhere is generally to be found.

The distinguishing features of seborrhoic dermatitis are given in the article on *Dermatitis Seborrhoica.*

Tinea favosa may be mistaken for pustular eczema. The crusts of favus are sulphur yellow in color and not greenish or brown from the drying of pus, as in eczema. The crusts of favus are cup-shaped and can be picked off, leaving a characteristic depression. The odor is distinctly mousy, and finally microscopical examination of portions of the crusts in favus will reveal the spores and mycelium, characteristic of that affection.

In tinea tonsurans the spot affected is covered with broken, short, twisted hairs, having the appearance of being singed, or the spot is devoid of hair. Eczema does not destroy the hair in this manner. Patches of ringworm are circular and often devoid of any inflammation or redness, those of eczema are red and inflamed and usually of irregular outline. Ringworm of the scalp is confined almost exclusively to children, while eczema occurs in both children and adults. The microscope, as in the case of favus, would definitely determine any doubtful case.

In pustular eczema of the scalp ointments of iodol, europhen, ichthyol, and white precipitate are especially effective. Iodol and europhen may be used in a strength of half a dram to the ounce of white vaseline, while ichthyol is most serviceable in a strength of from three to ten per cent. Five per cent. white precipitate is generally as strong as one can safely use.

For the chronic infiltrated patches occurring especially in the occipital region very vigorous treatment is generally needed. Salicylic acid, five to ten per cent., in alcohol; five per cent. of the same in diachylon ointment; six per cent. resorcin in equal parts of white precipitate and nitrate of mercury ointment; and unguentum picis et zinci are all useful in this condition.

In acute erythematous eczema, the tannin ointment referred to while discussing the local treatment of the disease, is the most useful remedy. Ointments of calomel, boric acid, and salicylic acid, and mild tar preparations will be found serviceable in the dry squamous types of the disease. In all cases the local treatment should be supplemented by the proper constitutional measures, if the best results are to follow.

Eczema of the Face.—The most common type of eczema of the face is the erythematous. It occurs in young, middle-aged, or elderly people, but is more frequently a disease of middle or advanced life. It is characterized by a dusky or bright-red, more or less diffuse eruption covering the cheeks, nose, eyelids, and forehead, stopping short usually at the border of the scalp and beard. The skin is swollen and at first smooth and tense; the eyelids are puffy, sometimes to the extent of complete closure; and when the disease is very acute, tiny vesicles develop upon the erythematous surface. Later in its course the disease loses its acute characters and assumes the aspect of a chronic process. It is accompanied by intense itching and burning; the skin becomes dry, scaly, and infiltrated, and the natural lines are exaggerated. Sometimes the itching is most intense, coming on in paroxysms, and the patient seeks relief by rubbing rather than by scratching. As a result of this the eyebrows are often rubbed off short, and the skin becomes steadily more infiltrated.

Eczema, as it occurs on the face of infants, has already been referred to and need not be further discussed in this place. Eczema of the face may occur as a part of a general eczema, in which case the entire face, including the ears, nose, lips, eyelids, cheeks, and forehead, is usually affected. These cases are generally chronic in character and are seen in the most typical form in strumous children. Erythematous eczema of the face is often mistaken for erysipelas and is often wrongly called "*chronic erysipelas.*" It is to be distinguished from that disease, however, by the absence of fever and general constitutional symptoms and by its very long and obstinate course.

In the acute form lotions of calamine and zinc, mild carbolic and boric acid lotions, the magnesia and zinc lotion previously mentioned, and dusting powders, are the most grateful kinds of applications. One or two per cent. of salicylic acid in gelanthum may be found of service in some cases. Ointments of oleate of zinc from half a dram to one dram to the ounce; of calamine, camphor, and zinc (formula already given); and of tannin and carbolic acid, may be advantageously used in alternation with the lotions.

In the chronic stage of the disease tar and mercurials may be used, first in moderate strength and later to produce their stimulating effects. The unguentum picis et zinci diluted one-half with zinc ointment; an

ointment of two per cent. salicylic acid and three per cent. of ichthyol; oil of cade from half a dram to one dram to the ounce of simple ointment; and white precipitate ointment of a strength of from three to five per cent. will all be found of service.

As in the treatment of eczema of the scalp the constitutional measures employed in conjunction with those used locally are of the greatest importance.

Eczema of the Beard.—The disease in this region manifests itself in two fairly distinct types. It occurs as a superficial inflammation of the skin, with redness, swelling, moisture, and crusting, or it quickly goes deeper and invades the hair follicles. In the latter case each hair pierces a pustule, and when removed carries the root sheath with it, in the form of a swollen, succulent bulbous extremity. It also affects the skin between the hair follicles, and often extends beyond the hairy region. The disease is accompanied by much soreness and pain, though itching is most complained of by some. The hair is often very greatly thinned, but generally it is reproduced after the disease has been cured.

On the upper lip a similar condition may occur, the lip being swollen, red, and covered with thick dirty crusts. This results from an extension of the disease from the nares or is caused by the acrid discharge from a chronic nasal catarrh.

Eczema of the beard usually runs a chronic course and is very difficult to manage in most cases; in some instances it is only a part of a more general eczema and requires the same treatment as eczema elsewhere.

Eczema barbæ is chiefly to be distinguished from coccogenic sycosis. Ringworm of the beard, with its deep-seated nodular masses, can scarcely be mistaken for eczema. Sycosis begins primarily as a folliculitis and invades the hair follicle to its depth in a very short time, and is accompanied by papules and tubercles which are never present in eczema. Eczema is a superficial eruption and invades the hair follicles secondarily. Sycosis is confined to the follicles as a rule, while eczema invades the skin between and may extend beyond the hairy region. The hairs in sycosis are loose and can be removed without pain. Those in eczema cannot be extracted without giving considerable pain.

The *treatment* of eczema and of sycosis are about the same. In acute cases, the remedies used for eczema in general should be employed. As soon as possible attempts must be made to shave, and the face should be kept shaved; it must be done at least every other day. At first it is a very painful process, but after a while patients are able to accomplish it without causing much pain.

In some cases it is good treatment to epilate the hairs. When the hair is surrounded by pus it is better to remove it, for it only acts as a foreign body. General epilation may be necessary in very chronic and obstinate cases. Salves or pastes are generally more useful than lotions. Sulphur in a strength of from ten to twenty grains to the ounce is one of the best remedies. Dilute nitrate of mercury ointment, red oxide of mercury ointment (two drams to the ounce of zinc ointment), three per cent. ichthyol ointment, oil of cade one dram to the ounce, and from one to three per cent. oleate of mercury, are all to be especially recommended in this form of the trouble.

Other forms of tar, as thiol, pix liquida, etc., may also be used with benefit in some instances.

Eczema of the Auricles.—Eczema may attack the auricles independently of any other region, or may extend to them from the scalp and adjacent localities. It generally affects both auricles and remains confined to them and is a disease which often recurs.

It is frequently dependent upon local causes, developing as a result of exposure to cold harsh winds, of sunburn, frost-bite, etc. It is likewise sometimes due to the presence of pediculi or is caused by infection from chronic aural discharges. The eruption occurs in the erythematous, vesicular, or pustular forms, and though some cases are acute, lasting but a short time, the majority are extremely chronic and rebellious to treatment. The disease generally begins with burning or itching sensations, followed by redness and great swelling. Vesicles soon develop which by rupturing either keep the surface moist or through drying give rise to serous crusts. The ears are often so stiff and swollen that they stand out some distance from the head, and the least movement causes the skin to crack in the angle of junction with the head. These fissures bleed and become exquisitely painful, and from their natural location are difficult to heal. In the chronic squamous form there is often much swelling of the external auditory canal, resulting in more or less deafness of a temporary character. The pustular type of the eruption is generally dependent upon pediculi, which must be discovered and removed before the trouble will yield. In the acute form the disease is sometimes mistaken for erysipelas, but its symmetrical distribution and general course, without constitutional symptoms, will always enable one to make the distinction.

The redness and swelling generally diminish rapidly under the use of the calamine and zinc lotion, or a lotion containing carbolic acid, gr. xv.; acidi borici, ʒ iss.; resorcini, gr. xx.; magnes. carbonat. and zinci oxidi, āā ʒ i. in four ounces of water. Dusting powders of talc and bismuth, or of stearate of zinc with salicylic acid, afford much relief in the acute stages. Mild ointments of bismuth, of boric acid, of oleate of zinc, and of calamine, camphor, and zinc, are all useful in the treatment of eczema in this region. In the pustular forms, iodol ointment in three per cent. strength, three per cent. white precipitate ointment, or ichthyol ointment of a strength of two or three per cent., with or without two per cent. of salicylic acid, will be found of great service. In the chronic squamous variety tar is especially valuable, notably solutions and ointments of pix liquida. Ichthyol in a five per cent. ointment is most effective in healing fissures, but it is generally necessary to bandage the ears to the head. Where there is much swelling of the external auditory canal, glycerite of tannin diluted about five times with water may be applied with a brush once or twice a day.

Eczema of the Lips.—Fortunately eczema in this locality is not very common, for, on account of the natural movements of the parts and the close proximity to the saliva, it is extremely hard to manage.

The disease occurs here in the vesicular, erythematous, and pustular types, and is characterized by redness, swelling, heat, and thick crusting, which is sometimes serous but more often dark and blood-stained. The lips become very sore and stiff and rhagades form, not only at the corners of the mouth but at various points along the lips. The process is kept up by the picking the lips are subjected to by the patient in order to obtain relief, and by being kept wet with the tongue and saliva to relieve the dryness and burning.

The disease may be confined to the vermilion border and corners of the mouth, but in some cases it extends some distance beyond, and may even be continuous with a similar eruption in the nares. This latter is almost always associated with a chronic nasal catarrh, which is the cause of the eruption also upon the lips.

Eczema of the lips is sometimes confounded with herpes labialis, and in some instances, especially in children, resembles syphilis. Herpes is an acute affection consisting of one or more separate groups of vesicles, which dry into thin crusts that are soon thrown off. Eczema is never so localized, is slower in its progress, and presents symptoms of a more pronounced inflammatory type. Syphilis in this re-

gion is accompanied by radiating cracks at the corners of the mouth which are quite deep and secrete a puriform fluid. The fissures in eczema are more superficial and bleed easily. In syphilis there would usually be evidence of mucous patches in the mouth or on the tongue, and in children snuffles and other confirmatory evidence of the disease could doubtless be found.

In the *treatment* of this condition much tact and ingenuity are generally needed. In male adults, the use of tobacco in any form must be prohibited and hot or irritating substances kept away from the affected region. In acute cases soothing emollients are called for and often a simple protective will prove beneficial. Lassar's paste is one of the most useful applications in the early stages; it is thick, and acts as a good protection and its effect is slightly astringent and soothing. Hyde recommends a lotion of equal parts of tincture of benzoin, alcohol, and glycerin.

I have found a lotion containing sodium biborate, ʒ ij., glycerin, ʒ iv., and rose water, ʒ iv., very useful in acute cases. Bismuth subnitrate, europhen, or oleate of zinc used in a tragacanth base, such as gelanthum, will also be found serviceable. The chronic cases often require very stimulating treatment with tar and potash solutions or by applications of nitrate of silver, chromic acid, etc. The fissures often heal rapidly after one or two applications of a silver-nitrate pencil.

Eczema of the Eyelids.—Both children and adults are affected with eczema of the lids. In children it generally occurs in strumous or ill-nourished subjects, while in adults it is frequently part of a chronic eczema in other regions. The disease attacks the free borders of the lids, which become red, swollen, and crusted. The hairs are affected early in the course of the disease, the inflammation extending to the depth of the follicle, producing a real sycosis of the lashes. The edges secrete a seropurulent discharge which agglutinates the lids and sometimes sets up a conjunctivitis. The free border of the lids may also be the seat of a dry, squamous eczematous condition, which is devoid of much inflammation, but causes more or less annoyance in consequence of the itching. In chronic cases of the sycosis type the lashes loosen or are pulled out, the edges of the lids become quite hard, very red, and either shiny or crusted, and the whole presents a very peculiar and characteristic deformity.

It is necessary to differentiate the disease from phthiriasis palpebrarum and from dermatitis seborrhoica of the lids. In the former, examination with a hand-magnifying glass will discover the crab-louse, if present, clinging firmly to the base of the hair. In seborrhoic dermatitis there is no free discharge or seropurulent crusting and very little evidence of inflammation. The scales are yellowish and greasy and there is no agglutination of the lids. Evidence of the disease would also be readily found upon the scalp or other regions.

In acute cases, with much burning, redness, and swelling, the closed lids may be bathed with warm boric-acid solutions. Calamine and zinc lotion, applied by soaking small pieces of lint and laying them upon the lids, also acts in a very soothing manner.

In the crusted variety, the crusts should be soaked off with salicylated oil in a strength of two or three per cent., or they may be picked off, after which the application should be made. An ointment of yellow oxide of mercury, three grains to the dram, may be used, or one of the red oxide diluted one to eight with cold cream. Another useful ointment is antimon. sulph., ʒ ss.; lanolin, ʒij.; vaselin. alb., ʒ iv. An ointment of one per cent. resorcin with two per cent. of salicylic acid, will also be found of value. Tannic acid, one dram to the ounce of rose-water ointment, is often effective, or glycerite of tannin may be painted along the lids in a very weak solution.

Suitable constitutional treatment is necessary in all these cases.

Eczema of the Genitals.—Eczema frequently attacks the genital organs of both sexes, and in this locality probably produces more acute suffering than in any other part of the body. In the male either the penis or the scrotum or both may be attacked, but eczema of the scrotum occurs most frequently. In women the entire vulva is generally involved, including the labia majora, labia minora, and vestibule.

The adjacent region of the groins is likewise often affected. The erythematous, papular, or papulosquamous types of the eruption are most commonly met with and occur in either an acute or a chronic form. Most of the patients who come for treatment have the disease in a chronic stage. The scrotum when acutely inflamed is red, hot, and swollen, the body of the penis and the prepuce are edematous and as a result of rubbing and scratching there is more or less moisture and scaliness. In women, the labia are much swollen, red and hot, and the whole vulva is moist and the parts are often agglutinated.

In some cases in both sexes the eruption is perfectly dry, there being no discharge, only erythema and scaliness accompanied by violent itching. In the chronic stage the scrotum is greatly enlarged, the skin is thickened, the natural lines are deepened, and there are often fissures, excoriations, and crusts produced by violent scratching. The color is a very dark red or it may be of a purplish hue.

The penis, prepuce, and glans may be the seat of chronic eczema, the skin and mucous membrane being densely infiltrated, red, and crusted. In chronic eczema of the vulva the parts are often lacerated greatly swollen, and thickened, and the vulvocrural juncture is the seat of a moist red or crusted eruption. The itching in genital eczema is very intense and paroxysmal in character, and efforts at relief result in severe laceration of the tissues.

The disease is one of adult or advanced life and rarely occurs in children.

The dependent position, the heat and moisture natural to this region, and uncleanliness on the part of the patient are responsible for most cases of eczema of the male genital organs. When the glans and prepuce are affected with chronic eczema, glycosuria is often present and is the cause of the trouble.

In women, vaginal and uterine discharges, together with heat, moisture, and uncleanliness, are the most frequent causes. Glycosuria should also always be suspected in chronic eczema of the vulva. In making the diagnosis of eczema of the genitals, it is necessary to exclude pruritus, ringworm, and pediculi pubis.

The *treatment* in the acute stage consists in the use of cooling astringent lotions and dusting powders. When the scrotum is affected, a snugly fitting suspensory bag should be worn. Calamine and zinc lotion, and a lotion of magnesia and zinc with two per cent. ichthyol will be found useful. Boric-acid ointment, or the ointment of calamine, camphor, and zinc, may also be used under these conditions.

Chronic eczema of the scrotum requires energetic stimulating treatment. Preparations of tar and mercury, both in lotions and in salves, will be found the most effective. Dilute liquor picis alkalinus, Vlemingkx' solution diluted to the extent of one to ten with water, equal parts of oil of cade or pix liquida and alcohol, three per cent. of salicylic acid with five per cent. of pyrogallic acid in alcohol, are all useful applications. A lotion containing magnesia carbonate and zinc oxide each ʒi., sod. salicylat. ʒiss., iatrol ʒiss., and water ʒiv., has proved useful in some cases. Applications of very hot water, for several minutes at a time, followed by a plaster of unguentum picis et zinci is a most valuable method of treatment. Tar and diachylon ointments and the various stimulating mercury ointments may also be employed. To reduce the thickening some use scarifications, galvanism, and paintings with liquor potassæ followed by the application of a soothing ointment.

Crocker treats the itching by placing a mustard leaf over the lumbar enlargement and gets better results than with anything else. Eczema of the vulva may be treated in about the same way, but the remedies must be a trifle milder. Dusting powders should be freely used in these cases in alternation with the lotions and salves mentioned.

Eczema of the Anus.—The disease in this region is very slow in its development and is always a chronic affection. When well marked it causes much distress and general suffering, and in the worst cases is so wearing upon the system that the patients sometimes become nervous wrecks. The affected part presents a red, roughened, puckered appearance, the tissues are greatly thickened, there are often considerable moisture and exudation, and here and there excoriations from scratching. Painful fissures are likewise not uncommon, and these may extend beyond the sphincter; they cause much pain in defecation. The eruption may be confined to the anus or may spread forward on the perineum or posteriorly toward the sacrum. The itching is very intense and generally persistent, though it is always much worse at night. In their efforts to obtain relief the patients often severely lacerate the parts, thus sometimes causing free bleeding.

Eczema in this region must be distinguished from pruritus, which shows no visible lesions except perhaps a few excoriations from scratching.

Syphilis would always exhibit flat papules or mucous patches, it is devoid of itching, and other evidence of that disease would usually be elicited. Eczema ani may occur in children or in adults, but it is more common in the latter and of most importance in them on account of its obstinacy. It is sometimes caused by constipation and hemorrhoids, but is more frequently dependent upon a gouty condition. In children it is due to parasites and lack of cleanliness in the care of those parts.

In the *treatment* of this condition, constitutional and local measures are essential. Diet and hygiene are most important, as well as proper regulation of the bowels and treatment for the hemorrhoids if present. Alcohol and tobacco should not be allowed these patients, for they particularly aggravate the condition. Both soothing and stimulating remedies are generally necessary. For use in the daytime calamine and zinc lotion is effective, and at the same time convenient. At night a stimulating ointment should be applied, and tar in some form is particularly valuable.

It is in eczema of the anus that hot-water applications are so beneficial. They are best employed at night and in the following manner: Cloths are wrung out in very hot water, as hot as the patient can bear, and are firmly held against the part for several seconds, being renewed as fast as they cool. After several minutes of this treatment the salve selected is immediately applied. This should be spread upon lint beforehand so that the parts are not unduly exposed to the air in making the application. Unguentum picis et zinci employed in this manner is very efficacious. Ointments of ichthyol, oil of cade, or thiol may be used in the same way. An ointment composed of equal parts of belladonna and diachylon ointments has proved valuable in some cases.

Fissures should receive special treatment, either by dilating the sphincter or by means of local applications. Burning with nitrate of silver or caustic potash is often successful in healing obstinate fissures.

Eczema of the Leg.—In elderly people of both sexes eczema of the leg is a rather common affection. It is more common in the poor laboring classes than in those higher in the social scale. In younger people it occurs in this region as a part of eczema elsewhere, but in older subjects the eruption is usually confined to one or both legs, and may last for years without any other evidence of the disease manifesting itself. It occurs usually in the erythematous-papular type, beginning often in the region of the ankle, and forming one or more patches, which may slowly enlarge and eventually coalesce to form a larger area.

When the affection has lasted for a long time, most of the cases being very chronic, it is frequently found to involve the entire leg. It will then appear in the form of a continuous patch of eruption, characterized by redness, edema or infiltration, weeping, and crusting. Some cases present a smooth red, moist, glazed condition, the skin itself being greatly swollen or infiltrated. This constitutes the eczema rubrum already mentioned. In other cases the discharge becomes purulent and the reddened skin is covered here and there with greenish, foul-smelling crusts which upon removal leave a red, oozing surface. Many cases are associated with varicose veins, part of the leg being the seat of pigmentation of a brown or dark-yellow color, while in other portions, particularly around the ankles, eczema occurs, often surrounding the limb. Complications sooner or later arise in the form of ulcerations which, when once developed, are very sure to recur, especially if the varicose condition is well marked. Eczema never causes ulceration, but this is produced by bursting of the veins and breaking down of the weakened skin. Eczema verrucosum and eczema sclerosum, previously described, result from very long-standing cases in aged people—cases which have been neglected or improperly treated.

The diagnosis of eczema of the leg is generally easy, the chief difficulty arising when ulceration, pigmentation, and scars complicate the disease. It is often very difficult to differentiate syphilis from an eczema thus complicated and in some instances it is quite impossible to do so. Syphilitic ulcerations, however, are usually multiple and occur most frequently in the middle or upper third of the leg. Scars from syphilis are generally thin, more or less round, and are surrounded by less deep pigmentation than are those which result from varicosities. Scars or other signs of the disease can often be found elsewhere. In women the history of miscarriages, still-births, etc., will help to confirm the diagnosis.

The *treatment* differs little from that of eczema in general, and many of the applications mentioned under local treatment would be of service in this condition. Dusting powders, evaporating, cooling, and drying lotions, such as calamine, magnesia and zinc, etc., are indicated. When there is oozing and profuse weeping, Kaposi advocates the employment of dilute solutions of acetate of aluminum, to be applied on compresses, while Crocker uses solutions of the lactate or subacetate of lead in the same condition. Salves of boric acid, bismuth, salicylic acid, ichthyol, etc., should be employed after the excessive discharge has ceased. Lassar's paste is a most valuable remedy and the glycero-gelatin or the "zinc-leim" of Unna finds its chief usefulness in eczema of this region. Ichthyol, salicylic acid, boric acid, or any other medicinal agent, may be incorporated with it as the case may require.

Support of the sluggish circulation and varicose veins is of prime importance in the treatment of these cases. When the patients cannot rest the leg, the applications can be made by spreading the salve upon lint and laying it over the diseased area, after which the leg should be firmly bandaged from toe to knee. Dressings should be applied twice daily, the bandage being dispensed with at night. The Martin rubber bandage answers admirably in some cases. It should be applied directly to the leg before rising in the morning and at night it is given a good washing and hung up to dry. Some cooling astringent lotion is then applied and by morning the leg is ready for the bandage again. In some cases the pure rubber sweats the leg excessively and causes pustules to develop. In these, the elastic webbing bandage may be substituted.

Eczema of the Hands and Feet.—The eruption is found here in all its typical forms and all the primary types of lesion may be seen at one time or another in the different cases. Thus we may have erythema, papules, vesicles, and pustules, together with the secondary changes, as squamæ, crusts, infiltration, fissures, etc. The disease may be either acute or chronic. In acute vesicular eczema, the sides and flexor surfaces of the fingers or toes and also the palms and soles are the seat of small vesicles, sometimes deep seated, at other times quite superficial. They are usually more or less grouped and in some cases coalesce to undermine sections of the skin with fluid. At these places the skin eventually peels off, leaving a red, new, thin skin, or one still eczematous, in which the disease presents the characters of a subacute or chronic squamous eczema.

Pustules may occur in the same manner on both the fingers and toes and palmar and plantar surfaces, in which localities they break or dry up into crusts, or form discharging patches. The erythematous, squamous, and papular forms of the eruption may affect the same regions, causing the skin to be dry, red, and scaly, and at the same time there are generally fissures at the flexures of the fingers, toes, or hands and also across the dorsal surfaces.

This type of eczema frequently affects the tips of the fingers, making them dry and fissured and very sensitive and painful at the slightest touch. Squamous eczema of the palms and soles occurs in small patches, scaly, red, and fissured, or it may cover the part diffusely with the same dry, red, fissured eruption, extending even on to the dorsum of the member.

The *palms* and *soles*, from their special anatomical make-up, present features peculiar to themselves. The thickness of the horny layer determines the character of the lesions when the part is affected with eczema. The skin becomes thickened, hard, rough, and dry either in localized portions or diffusely. Sometimes true callosity exists, and from the great thickness and stiffness of the parts, deep, painful, and bleeding fissures generally develop. As in all the other forms of eczema of the hands and feet, one or both of the members may be affected, but generally the hands and feet are not affected at the same time.

The causes of eczema of the hands and feet are numerous. Many cases of acute vesicular eczema are dependent upon a gouty state of the system or upon a nervous, over-worked, or run-down condition. Eczema of the palms and fingers is often due to the occupation and constitutes in many cases examples of what is described as "*trade eczema.*"

The diagnosis of vesicular or pustular eczema of the hands and feet is sometimes attended with difficulty. It often resembles scabies or the dermatitis produced by the poison ivy or poison oak. Scabies produces, as a rule, larger blisters which are more scattered, usually affecting all the fingers and especially the interdigital spaces. Eczema does not often involve all the digits, and the vesicles or vesicopustules are more grouped.

The burrows of the itch mite can almost always be found by careful examination, and there would almost invariably be evidence of scabies in the other favorite sites for the disease. Dermatitis venenata, from *Rhus toxicodendron* or the poison oak, is very acute in its onset and course. It covers the hand and fingers and extends beyond them in a very short time, and similar irritative lesions quickly develop upon the face and genitals which would at once distinguish it. The history of exposure to such infection can often be readily obtained.

Syphilis resembles the squamous palmar and plantar forms of eczema very closely at times. Syphilis, however, begins as papules in the form of deep-seated or shotty, red nodules which are arranged in a circular or crescentic form. These coalesce to form a circinate patch, which spreads slowly over one or both palms or soles, even extending over the sides of the part affected. The fissures and scales which sometimes form are like those seen in simple eczema and can scarcely be distinguished from them; the diagnosis must rest mainly upon the method of evolution and the history and evidence of syphilis in other parts. Psoriasis of the palms and soles is so rare that to enumerate the diagnostic points is hardly necessary. It may be mentioned, however, that psoriasis almost invariably presents lesions elsewhere at the same time.

The *treatment* for acute vesicular or pustular eczema of the hands and feet is the same as that employed for the disease when it affects some other part of the body. Soothing and drying lotions, dusting powders, and protection from soap and water, from irritating substances used in the occupations, etc., are the measures indicated. In neurotic or gouty subjects the proper constitutional remedies, diet, hygiene, etc., should be instituted. In squamous eczema of the palms, soles, fingers, or toes, tar and the mercurials are particularly effective, though care must be taken not to employ them too strong. White precipitate ointment, citrine ointment, the red oxide and calomel ointments are all useful. For the fingers an ointment of iatrol, ʒss.; acidi salicylici, gr. x.; sod. salicylat., ʒss.; zinci oxidi, ʒss.; and gelanthum, ʒi., is often effective.

Lassar's paste and Unna's zinc-gelatin paste, with or without ichthyol, are particularly valuable.

In palmar and plantar eczema the thickened epidermis should be first removed by the application of five to ten per cent. salicylic plaster, or by means of pumice stone, or by the use of caustic potash, ten to fifteen grains to the ounce. If fissures are present these remedies must be used with care. After the calloused epidermis has been destroyed, ointments of salicylic acid, as the Lassar paste, and those containing thiol, oil of cade, ichthyol, pix liquida, or the various forms of mercury, should be used.

The fissures may be successfully treated by cauterizing with the nitrate of silver stick.

Eczema of the Nails.—One or several nails may be affected with eczema, but it rarely attacks all at the same time. Generally it concerns the finger nails alone, but occasionally some of the toe nails are simultaneously diseased. The symptoms are those dependent upon defective nutrition of the nail, and this in turn is due to changes in the matrix effected by the eczematous process. Eczema of the finger tips or of other parts generally accompanies the nail disease. The nail loses its lustre, becomes roughened and furrowed, is often distorted and greatly thickened, or it may be covered with small pittings, giving it a honeycombed or worm-eaten appearance. In some cases the nail becomes brittle and flakes off, while in others the thickened mass crumbles at the sides and tip, and gradually wears the nail away to a short stub. The nails are rarely shed entire, however, except in universal and very severe cases of the disease.

Eczema of the nails is to be distinguished chiefly from favus and ringworm and from psoriasis and syphilis. Scrapings from the crumbling portion of the nail, examined by the microscope in equal parts of liquor potassæ and glycerin, will reveal the fungus of favus or ringworm if present. Psoriatic and syphilitic nails show no distinctive differences in some stages from those affected with eczema. The physician must rely upon the history, upon the presence of other lesions than those of the nail, and upon the general course of the disease in either case.

The effect of treatment in eczema of the nails is slow. General tonics of arsenic, iron, cod-liver oil, etc., should be given continuously; arsenic alone has but little effect upon the disease. Locally, the nails should be scraped and dipped into extremely hot water for ten or fifteen minutes every night, after which they should be done up in some ointment or oily preparation. The oleate of mercury, five to ten per

cent., Hebra's diachylon ointment, the unguentum picis et zinci, the white precipitate, or the nitrate of mercury ointment—any one of these may be used for this purpose. I have found an ointment of resorcin, gr. xl.; stannic. oleat., ʒss.; lanolin, ʒij.; and ungt. aquæ rosæ, ʒvi., of much service in treating eczema of the nails.

In all cases it is advisable to protect the nails with finger cots during the day, whether or not it may be possible to keep an application upon them.

HENRY H. WHITEHOUSE.

**Edema.** — Hydrops, dropsy. An increase in the amount of lymph within the tissue spaces or serous cavities is known as *edema* or *dropsy*. The fluid itself is often called a *transudate;* but at the present time the distinctions formerly held between edema and inflammatory exudate, and transudate and exudate, are no longer emphasized, inasmuch as the essential etiological factors are common to both. Various specific terms are employed to denote the portion of the body affected by the condition of edema, as, for example, *hydrops* is usually limited to the collection of fluid within the body cavities; *edema* to the collection of fluid within the lymph spaces of the connective tissue or parenchymatous organs; *anasarca* or *hyposarca* to an edematous condition of the skin or subcutaneous tissues; *ascites* to the collection of fluid within the peritoneal cavity; while *hydrothorax, hydropericardium, hydrocele, hydrophthalmos, hydrocephalus internus, hydrarthrosis, hydrops bursarum,* etc., are used to designate the collection of fluid in the pleural cavity, pericardium, scrotum, eye, cerebral ventricles, joints, bursæ, etc., respectively. Such terms as hydrocele, hydrosalpinx, hydrometra, hydrops vesicæ felleæ, hydronephrosis, etc., are applied to collections of fluid resulting from chronic inflammatory processes or retention of secretions, rather than to true edemas. Localizations of edema of great importance clinically are designated as *edema of the lungs, edema of the glottis,* etc. The edematous swelling of the presenting portion of the fetal head is known as *caput succedaneum.* Edematous conditions of the conjunctiva are termed *chemosis serosa.* The term *dropsy* in strict use should be confined to the collection of fluid within the body cavities, but is applied in a loose way to any edema or collection of fluid of such extent as to be evident by the ordinary methods of physical examination.

*Lymph.*—Since edema is a pathological increase of the lymph, it follows that the production of the former must depend upon a disturbance of the normal mode of lymph production. The clear watery fluid which permeates the intercellular spaces of the tissues and bathes the serous surfaces is known as the lymph. Its chief source is the blood, and its constituents are passed through the walls of the blood-vessels by processes of diffusion, filtration, and specific secretory activity of the cells of the vessel walls. Under certain conditions the fluid of the cells and other constituents of the tissues may also pass into the free fluid of the tissue spaces. According to Heidenhain the lymph is composed of fluid derived from the blood, the lymph of the organ under consideration, and the water contained in the tissue cells and fibers. The ultimate source is, of course, the blood. Formerly regarded as a passive filtration from the blood-vessels, the formation of lymph is now considered by the majority of investigators to be in part of the nature of a secretion of the cells forming the capillary walls and in part the result of filtration and diffusion. In support of the view of the selective action of the blood-vessel walls are the facts that the composition of the lymph differs greatly from that of the blood plasma, and differs also in its composition in different parts of the body; further, under certain conditions it may contain more salts and extractives (urea and sugar) than the blood. The rapid passage of crystalloid substances from the capillaries into the lymph is also a strong point in favor of the view that the process is not one of mere diffusion, but is the result of a force inherent in the cells of the vessel walls. According to Heidenhain the specific function of the capillary walls play controlling part in the formation of lymphs. Certain substances injected into the blood-vessels increase the production of lymph (extracts of leeches, mussels, crabs, peptone, etc.); and it is also possible that the capillary secretion is directly under nerve influence. It is very probable that certain edematous conditions of the skin (urticaria, herpes zoster, etc.) are partly intoxications and in part due to nervous disturbances. The function of the lymph is the conveyance of nutrition to the cells and the removal of their waste products. The ability of the tissue-elements to hold or to give up water, depending upon the colloidal conditions of the tissue, has in recent years been regarded as a factor in the production of lymph. From the lymph spaces the fluid is gathered into the lymph vessels passing to the lymph nodes, from which it is passed on to the veins by the larger lymph trunks. Not all the lymph is returned in this manner; a portion is undoubtedly taken up directly into the blood-vessels; or at least in some of the lymph nodes a portion is taken up by the capillaries of the lymphoid tissue. Normal lymph has the same salt-content as the blood, corresponding to about 0.9 per cent. sodium chloride solution. It contains less albumin, and does not coagulate spontaneously. It contains but few cells, the majority of these being lymphocytes.

ETIOLOGY OF EDEMA.—It follows that as edema is the result of an increase in the amount of lymph, such an increase may be brought about either by an increase in the amount of fluid passed out of the capillaries or by some obstruction to the outflow of lymph through the lymphatics or to changes in the water-content of the tissue-elements. In general, the causes of edema are the various pathological conditions which may influence the process of lymph formation. The increased production of lymph may be due to an increase of the vascular secretion, or to an increased permeability of the vessel wall. These conditions may be brought about by increase of blood-pressure, by pathological alterations in the vessel walls, or by the direct action of certain substances either upon the cells of the vessel walls or upon the nerves governing these, stimulating the capillaries to increased secretion. Within certain limits an increase in lymph production is equalized by an increase in lymph absorption through the lymphatics and also through the blood-vessels. Beyond this limit there arises a more or less permanent oversaturation of the tissues with lymph, and the condition of edema is established. The lymph may be held back in the tissue spaces because of differences in the osmotic pressure or because of some hindrance to its flow into the great lymph trunks. In the majority of cases all of these etiological factors play a part in the production of the edema, and it may be very difficult to determine the share played by each one. Further, it is often difficult to distinguish between transudates and inflammatory exudates.

According to etiology five general classes of edema may be distinguished: *edema due to arterial congestion, edema from stagnation of the blood,* that resulting from *obstruction of the outflow of lymph,* that caused by *changes in the vessel wall* and *edema ex vacuo.* Clinically, a great number of varieties may be recognized: *toxic, thermal, traumatic, inflammatory, cachectic, infectious, hydremic, anemic, neuropathic,* etc., but all of these fall within the four etiological classes above named, the great majority belonging to the fourth class, namely, that produced by disturbances of the capillary secretion through alterations in the vessel walls.

ETIOLOGICAL VARIETIES OF EDEMA.—*Edema Due to Arterial Congestion.*—This occurs as an acute and sharply localized edema in the skin, mucous membranes

of nose, larynx, and bronchi, muscles, periosteum, etc., and is usually *neurotic* in character. The condition may be inherited, and individuals showing it to a marked degree may present marked swellings of the mucous membranes or even bullæ of the skin. According to some writers an uncomplicated increase of arterial pressure leads only to an increase of the lymph, but not to edema unless the outflow of lymph is obstructed.

*Edema of Stagnation.*—Following an obstruction to the onward flow of the blood, resulting from ligation or occlusion of the main venous trunks, or in general venous congestion, due to insufficiency of the heart, the capillary pressure rises and an abnormal secretion of lymph takes place. That the edema is due directly to the increased blood pressure within the capillary cannot be said to have been definitely proved. It is probable that as a result of the increased pressure the cells of the capillary walls are stimulated to increased secretory activity. It is also probable that degenerative changes in the endothelium result from the distention of the vessel, and the consequent impairment of nutrition so that as a consequence of an increased permeability of the wall serous transudation occurs. The fact that in many cases no changes in the vessel walls of an edematous area can be found favors the theory of increased secretion. In chronic congestion the occurrence of edema is also favored by the resulting loss of elasticity of the tissues about the vessels. An increase of arterial pressure does not give rise to edema so long as the venous return is unimpeded, but in all cases of passive congestion there is an increased formation of lymph. This may be compensated for by an increased flow of lymph, but beyond a certain limit the fluid collects in the tissues. In cases of general passive congestion the edema first shows itself in the most dependent parts of the body, the influence of gravity favoring the greatest increase of pressure in the vessels of these parts. As in general passive congestion there is some obstruction to the discharge of the large lymph trunks into the veins because of the increased venous pressure, the lymph of the tissues is not removed as rapidly as normally. Local passive congestion gives rise to local edema; mild grades of Bier's hyperemia cause some increase in the tissue fluids; thrombosis of the femoral vein causes edema of the lower extremity, occlusion of the portal circulation is followed by ascites, etc. A general edema due to venous stagnation occurs in cardiac insufficiency. The condition of the heart is also of great importance in determining the occurrence of edema due to local venous stagnation; as, for example, obstruction of the crural vein will not be followed by edema if the heart's action is strong. Edema of the lung is usually a pure stagnation edema resulting from insufficiency of the left ventricle; but in some cases it is inflammatory or the result of a damage to the vessel walls. In many cases the stagnation edema of the lungs is an agonal or terminal phenomenon without clinical significance. The fluid in edema of stagnation always contains but a slight amount of albumin. With increase of pressure the amount rises, and a varying number of red cells may escape from the vessels into the lymph.

*Edema Caused by Obstruction to the Lymph Circulation.*—It has been shown by a number of investigators that obstruction to the current in the lymph vessels is not as a rule followed by edema, on account of the numerous and universal collateral anastomoses, and also for the reason that the lymph may be reabsorbed by the blood-vessels. An actual obstruction to the lymphatic circulation can, therefore, hardly occur except in the case of the main lymphatic trunks. Even in these cases, if the production of the lymph remains normal, collateral channels may be developed sufficient to carry off the lymph without causing edema. According to Baldaert the total occlusion of all the lymph vessels of a part may give rise to a pure lymphatic edema, which in the case of increased formation of lymph may develop into a tissue edema. Obstruction of the thoracic duct by tumors, aneurysms, etc., is usually followed by chylous ascites and more rarely by chylopericardium and chylothorax. Even in this event a collateral circulation may be set up; but in other cases the rupture of the receptaculum chyli gives rise to a chronic chylorrhea into the peritoneal cavity. In the case of edema caused by venous stagnation lymphatic obstruction causes a great increase in the degree of the edema present. Destruction of the regional lymph nodes by metastatic carcinoma, surgical operation, chancroidal bubo, tuberculosis, etc., may cause a severe edema of an extremity in case venous congestion is also present. Severe edema of the arm sometimes follows the removal of the axillary gland for carcinoma of the breast. The edema of elephantiasis lymphangiectatica is not simply the result of an obstruction to the lymph return but is of the nature of a chronic inflammation.

*Edema Caused by Disturbances of Capillary Secretion.*—As the result of chemical changes in the blood, imperfect oxygenation, anemia, infections, intoxications, long-continued passive congestion, trauma, effects of low or high temperatures, etc., certain pathological alterations in the walls of the vessels may be produced, of such a nature as to cause an increase in the secretion of the vessel walls and give rise to edema. The exact nature of the changes we are at present unable to state; in some cases the endothelial cells appear granular, cloudy, and are exfoliated; in other cases no changes in the cells can be discovered. It is also possible that alteration of the cement substance between the cells favors an increased transudation of fluid. The forms of edema produced by the above-named factors are known clinically as toxic, infectious, neuropathic, inflammatory, cachectic, etc.

*Edema ex Vacuo.*—After degeneration or necrosis of portions of the tissue of brain or spinal cord the necrosed material is absorbed and the defect becomes filled with fluid of a very low specific gravity and containing but a small amount of albumin. In atrophy of the brain and cord (senile atrophy, progressive paralysis, cerebral syphilis, tabes, etc.) the subarachnoidal space (pia edema) and the ventricles may become enlarged and filled with a similar fluid. This process may be regarded as being of the nature of a compensatory attempt to restore the normal tension of the part.

Nature of the Transudate.—The fluid of edema is usually colorless or pale yellow, clear, and of alkaline reaction. A few leucocytes and red cells are usually present. In cases with accompanying icterus the fluid may be yellow or even brownish. An excessive number of red cells may give it a reddish tinge. The collections of fluid in the serous cavities are more likely to vary in color in a noticeable degree, and usually contain flakes of fibrin. Occasionally they may contain large numbers of desquamated endothelial cells, leucocytes, or fat droplets. After rupture of chyle vessels the admixture of chyle with the fluid of an existing ascites may produce a milky turbidity of the ascitic fluid. In other cases the milky appearance of transudates may be caused by a precipitation of albumin (lecithin-globulin combinations). A *hydrops adiposus* may also be mistaken for chyle. The milky appearance of the ascitic fluid may be due to the presence of fine fat droplets arising from the disintegration of the cells of inflammatory exudates, mesothelium, or neoplasms. The chemical composition of transudates is closely related to that of the blood plasma. The amount of proteins, salts, and extractives is a varying one, and is usually less than that of the blood. Under certain conditions the salts and extractives may occur in greater amounts than in the blood, but the amount of albumin is

always much less. The fibrin-forming elements may be absent or present in small amount. Mucin is occasionally present. The proportion of albumin in pure transudates varies greatly in different parts of the body. According to Reuss, the proportion of albumin in pleural transudations is 22.5 *per mille*, in pericardial 18.3, in peritoneal 11.1, in the fluid of subcutaneous edema 5.8, in that of cerebral and spinal cavities 1.4.

The following table of the specific gravity and albumin content of certain transudates is given by Thoma:

| | Specific gravity. | Per cent. of albumin. |
|---|---|---|
| Ascitic fluid in nephritis | 1.006 | 0.56 |
| Ascitic fluid in portal obstruction (cirrhosis). | 1.008 | 0.97 |
| Ascitic fluid in general venous congestion. | 1.012 | 1.96 |
| Pleural effusion in nephritis | 1.007 | |
| Pleural effusion in general venous congestion. | 1.012 | 1.30 |
| Transudates of varying origin | 1.007–1.011 | 0.05–1.1 |

As a rule the specific gravity of a pure transudate rarely reaches 1.010, usually falling below, 1.006–1.008. In inflammatory edema the specific gravity may reach 1.016–1.020. In inflammatory edema the amount of albumin is much greater than in pure transudates. As far as chemical relations are concerned there is no sharp boundary between the fluid of transudates and that of exudates. The presence of abnormal substances in the blood plasma (sugar, uric acid, bile pigments, cholesterin, potassium iodide, phenol, etc.) leads to the presence of the same in the fluids of the tissues and body cavities.

General Morbid Anatomy.—Edematous tissues are usually pale, swollen, and as the result of the deficient circulation colder than normal. The degree of change varies with the part involved and the structure of the tissue. The skin and subcutaneous tissue may take up an enormous amount of fluid; the skin may become greatly stretched, and an extremity may swell to many times its normal size. As a result of the extreme distention the skin at first becomes greatly thinned, smooth, and shining, but later presents linear lines of rupture from which spontaneous oozing of fluid may occur; in chronic edema the skin usually becomes thickened, rough, scaly, and pigmented, and may show numerous lineæ albicantes. The most characteristic physical sign of edema is that of pitting on pressure, indentations made with the fingers in edematous tissues persisting for some time, because of the diminished elasticity of the tissues. The lymph spaces of the skin and subcutaneous tissues may become so dilated that incision into these allows the fluid to escape in a constant stream. The appearance of the incised tissue is that of a partial liquefaction, so great may be the saturation with fluid. Edema of the skin usually appears first over the ankles and beneath the eyes. The loose integument of the penis and scrotum may show the most extreme degree of saturation.

Collections of fluid in the body cavities (ascites, hydrothorax, etc.), when extreme and long continued, cause dilatation of the cavity and compression of neighboring organs. The cavity may contain many liters of a clear, light amber fluid, usually poor in cells. The serous surfaces become grayish and more opaque and usually present more or less desquamation. The surface, however, remains smooth and shining if inflammation is absent, while in the case of inflammatory exudates it is roughened, dull, injected, and covered with fibrinous exudate. In edema of mucous membranes the mucosa becomes swollen, pale, grayish, more or less translucent, and of boggy consistence. In the case of the lung the alveolar spaces become filled with fluid, the presence of the fluid causes a loss of elasticity and a partial atelectasis. On section a more or less abundant frothy fluid escapes from the cut surface. In marked pulmonary edema the volume and weight of the organ may both be greatly increased. Solid organs like the liver and kidney from the nature of their structure rarely show a marked condition of edema. When present, the cut surface of the organ is moist and glistening. Postmortal diffusions of fluid must be differentiated from intravital effusions. Intravital effusions are usually clear, and become cloudy or sanguinolent only after some days after death. The postmortal diffusions are at first clear, but quickly become cloudy and sanguinolent.

The microscopical examination of edematous tissues shows enlargement of the tissue spaces, separation of the connective-tissue fibrillæ, vacuolization of cells and nuclei, and the presence of fine albumin granules in the spaces occupied by the fluid. In the alveolar spaces of the lungs large numbers of desquamated epithelial cells are also found. In chronic edema hydropic degeneration of some of the constituents of the tissue may take place. As a result of the lowered resistance of edematous tissues, and the mechanical injury caused by stretching, distention, etc., secondary inflammatory changes are of frequent occurrence in and about edematous tissues.

Clinical Varieties of Edema.—*Inflammatory Edema.*—The edema associated with inflammatory processes is not of the nature of a pure transudate, but is usually classed under the head of exudates. Its etiology is, however, to be sought in alterations of the vessel wall similar to those which give rise to transudates, though of a more marked character. It occurs as circumscribed or diffuse swelling of tissues, or as effusions into the body cavities. It differs from transudates in the character of its fluid, which contain much more albumin and greater numbers of red cells and leucocytes, and a much greater proportion of fibrin-forming elements. It may be caused by any of the factors—infectious, toxic, traumatic, thermal, etc.—that give rise to inflammation. The edema often seen in the neighborhood of inflammations is known as *collateral edema*, but it is still doubtful whether this should be classed as a transudate or an exudate. It contains more leucocytes than the ordinary transudates. Inflammatory edema is regarded by some writers as representing the transition stage between the vascular changes that give rise to pure transudates or edema, and those which lead to inflammatory exudation. The changes in the serous surfaces are of greater importance in differentiating transudates and inflammatory exudates than the chemical character of the fluid.

*Toxic.*—Heidenhain found that intravascular injections of the enzymes of the salivary, pancreatic, and gastric secretions, peptone, egg albumin, decoctions of the muscles of crabs and crayfish, etc., produced a marked increase in the production of lymph. He explained this phenomenon as due to the stimulation by these substances of the secretory functions of the cells of the vessel walls. According to Hamburger bacterial products circulating in the blood may either increase the permeability of the capillary wall or stimulate the endothelial cells to an increased or abnormal secretory function. A changed chemical condition of the blood may have a similar action. Toxic edemas are produced especially by bacterial toxins (diphtheria, influenza, measles, scarlet fever, acute arthritis, streptococcus infections, etc.), snake bite, stings of insects, injection of foreign protein (serum disease, hypersensitization, anaphylaxis, etc.), and by various chemicals (petroleum, mustard, croton oil, styrone, etc.). Toxic edema may be local or general. It may appear in the form of urticaria, or as effusions

into the serous cavities. It has been suggested that edema may be caused by a lack of oxygen, the resulting chemical changes in the blood or tissues causing an increase in osmotic pressure in favor of the tissues over the blood or lymph. The edemas formerly regarded as *cachectic* or *hydremic* are most probably caused by the altered functional activity of the endothelium due to changes in the composition of the blood. The edema of chronic nephritis may be explained in the same way. The acute edematous conditions of the skin, such as urticaria, are also due wholly or in part to intoxication. The injection of certain protective or curative serums (plague serum) may be followed by extensive urticaria, or even by a more generalized edema. In the autointoxications of the food idiosyncrasies (lobster, strawberries, mushrooms, etc.) transitory edemas of the skin also occur in the form of urticaria. An experimental edema of the lung may be produced by muscarin poisoning, or by the injection into the air passages of various irritants. Such an edema must be closely related to inflammation, and no sharp line can be drawn between the two processes.

*Hydremic or Cachectic Edema.*—It was formerly held that an hydremic condition of the blood, due either to a diminution of the solids of the blood or to a retention of water, could be a direct cause of an increased transudation through the vessel walls. The latter were believed to behave as dead animal membranes, and the process of edema formation to be one of pure osmosis. It was shown by Cohnheim that hydremia was not the direct cause of edema. Even when the blood is replaced to the extent of one-half its volume by decinormal salt solution, so that there is produced a marked hypoalbuminosis, no edema is caused. In extreme hydremic plethora, edema may supervene when the amount of water in the blood becomes very great; but it does not develop in the same regions where edema ordinarily is found. Further, the occurrence of one-sided hydrothorax, or of bilateral hydrothorax with unequal amounts of fluid in the two pleural cavities, must be taken as strong evidence of differences in the structure and function of the capillary walls in the two sacs. In general it may be said that hydremia does not produce edema, but only favors its occurrence. The edemas which occur in chronic anemia, cachexias, chronic nephritis, etc., are therefore, to be regarded as due to changes produced in the vessel walls by the altered condition of the blood or by poisons circulating in the blood. The edema due to nephritis is from the practical standpoint one of the most important forms of edema. It occurs most frequently with the nephritis of scarlet fever and pregnancy, and in chronic parenchymatous nephritis, while it is of less frequent occurrence in primary contracted kidney. Its occurrence is not dependent upon the severity of the nephritis.

It begins usually in the loose subcutaneous tissues of the face, and gradually extends over the entire body. Many theories have been advanced to explain its formation. The excretion of albumin, the deficient excretion of sodium chloride, the damage to the blood-vessels, and changes in the secretory power of the endothelium are all urged by different writers in explanation of the chief symptom of chronic Bright's disease. Much experimental work has been done in recent years in the attempt to solve this problem. In the uranium nephritis produced experimentally in rabbits marked edema results. The blood serum of animals poisoned with uranium will produce edema in other animals when injected into them. It has also been shown that the blood serum of edematous nephritics will produce an increased formation of lymph in animals into which it is injected. These experiments are of great interest in connection with the fact that in the nephritis of pregnancy the fetus is usually edematous. By Thoma and other writers it is believed that cachectic and hydremic edemas are due to sclerotic changes in the vessel walls (*angiosclerotic edema*). A loss of elasticity of the tissues may also favor the formation of edema in these conditions. The fluid of hydremic or cachectic edema contains but a small amount of albumin as compared to inflammatory edema.

*Neuropathic Edema, Angioneurotic Edema.*—If the production of lymph is dependent upon a secretory function of the vessel walls it is very probable that such function is under nervous control, and that under certain nervous disturbances an edema may arise which may properly be designated as neuropathic. This is borne out by many clinical observations. In hysterical individuals and in persons who have been hypnotized localized edemas may occur that admit of no other explanation. In epilepsy pale or red areas of angioneurotic edema are not infrequently seen, in the shape of wheals, general urticaria, etc. In Basedow's disease urticaria not infrequently occurs, as well as circumscribed, unilateral edema localized in the hands or legs. Erythema nodosum and herpes zoster are also regarded as partly toxic and partly neuropathic. Edema also occurs after spinal paralysis; and in hemiplegia the affected side shows a more or less well-marked edema. The most striking form of neuropathic edema is the acute circumscribed angioneurotic edema which affects particularly the glottis and may lead to death from suffocation. The edema may be localized also in the skin, nose, lungs, stomach, or genital tract. Closely related to this form is the generalized idiopathic edema that runs a more chronic course. Both forms may be inherited. According to Janowski the severing of the vasomotor nerves in conditions of edema is followed by a great increase in the amount of the exudate. Experimental edemas in animals may also be produced by the irritation of certain nerves, as in the case of the dog stimulation of the lingual nerve leads to edema of the tongue. Vasomotor disturbances in myelitis, tabes, sciatica, facial neuralgia, etc., are also associated with the production of edema. Toxic, thermal, or traumatic irritation of the nerves may also lead directly to edema. Anything that stimulates the vasodilators or causes paralysis of the vasoconstrictors leads to vascular dilatation and the production of edema. It must be borne in mind, however, that many writers hold that the existence of a purely neuropathic edema has not yet been proved.

*Edema Fugax.*—The majority of the so-called neuropathic edemas are of fleeting nature. Transitory edema is of not infrequent occurrence in Basedow's disease, chlorosis, severe anemia, hysteria, etc. Such edemas usually appear during the day and disappear after a night's rest.

*False Dropsy (Hydropsia Spuria).*—The distention of cavities, chiefly those of glands, following stenosis or obliteration of the gland duct is so classed. The fluid usually results from the retention of secretions; it may be a thin serous or a thickened mucous fluid. In this class belong hydronephros, hydrosalpinx or hydrops tubæ, hydrops cystidis felleæ, hydrometra, hydrops processus vermiformis, hydrops sacci lacrymalis, etc.

*Edema Intermittens.*—Intermittent edema has been described in cases of malaria, and in febris intermittens larvata. The whole body surface may be involved, but often the edema is confined to the extremities, thorax, etc. Intermittent ascites and intermittent hydrarthrosis have also been observed.

*Edema Neonatorum (Sclerema* or *Scleroma Neonatorum).*—A condition of the skin of the new-born characterized by an infiltration of serum into the subcutaneous tissue, hardening of the skin, and lowering of the skin temperature. Many theories have been adduced in explanation of this condition, but it is probable that it represents a symptom complex and not an independent disease. The majority of children affected are those born prematurely. The affection begins usually on the second to the fourth day. After the eighth day it is very rare. Congenital cases

have been observed. In the majority of cases the condition is fatal. The edema has not been satisfactorily explained, but is probably due to changes in the blood following cardiac insufficiency, deficient oxygenation, and changed chemical nature of the blood in some cases due to intestinal intoxication. D'Agata is of the opinion that the condition is of the nature of a vasomotor and trophic vagus neurosis.

Occurrence of Edema.—Edema is of most frequent occurrence in all forms of cardiac insufficiency, especially failure of compensation in valvular disease, chronic nephritis, cirrhosis of the liver, chronic anemias, and cachexia, conditions in the lungs favoring venous stasis, thrombosis of large veins, or obstruction of these by tumors. In cases of hemophilia after repeated hemorrhages edema often occurs. Myelitis with decubitus is often associated with edema of the lower extremities. Mediastinal tumors, or growths arising in the lungs or bronchial glands, or aneurysm may cause edema of one-half the body through pressure upon the large veins. In chronic chloral poisoning general edema of the skin occurs, and in chronic morphinism edema of the face has been observed.

In both acute and chronic rheumatism circumscribed or diffuse edema often appears in various parts of the body; in chronic rheumatism it is not infrequently associated with arteriosclerosis, particularly of the arteries of the foot and of the tibialis posticus. Edema is also often associated with arteriosclerosis dependent upon other causes, vessel walls which show sclerotic changes being more permeable than normal vessels. In cases of cancer and ulcer of the stomach edema may occur after severe hemorrhages. In chronic tuberculosis it is of less common occurrence. In this disease it is more often confined to one of the lower extremities, usually the left, as the result of marantic thrombi in the crural vein or some of its branches. When double-sided the edema is due to cardiac insufficiency or to the changed condition of the blood. The development of amyloid disease or tuberculous peritonitis usually leads to extensive or general edema.

Edema of the larynx occurs in laryngitis, nephritis, malaria, cardiac insufficiency, enlargements of the thyroid, aortic aneurysm, pressure of tumors upon the jugular veins and their branches, after the use of potassium iodide, inhalation of hot air, in acute infections, (variola, typhoid, etc.), in leukemia, and in tuberculosis, syphilis, and carcinoma of the larynx, etc. An idiopathic or neuropathic form of edema of the glottis (Quincke's edema) occurs in association with general nervous disturbances. Edema of the pharynx occurs in the same conditions, but most frequently in scarlet fever and in chronic nephritis. The edematous mucosa is swollen, translucent, and pale, these changes being most marked over the soft palate and uvula. The latter organ may be greatly increased in length and thickness and may cause serious disturbances of respiration.

Edema of the lung occurs especially in cardiac insufficiency, chronic nephritis, in connection with inflammatory conditions of the lung, and also in association with cerebral disease. Marked edema of the penis and scrotum is very common in cases of extensive general edema. Local edema of these parts occurs in cases of stricture, traumatic injury of the urethra, bladder, and seminal ducts, in infiltrations of urine, in syphilis, and after operations upon the bladder or rectum as one of the first signs of a phlebitis in the plexus prostaticus. There appears also to be an idiopathic form of edema of the penis. In chronic edema of this organ there often results a marked phimosis and a thickening of the mucous membrane of the external meatus. Edema of the external female genitalia occurs after difficult labor, in cases of ovarian or uterine tumors, in abnormal position of the uterus, prolapse, etc.

In cases of infection with the bacillus of malignant edema there develops very rapidly a general subcutaneous edema, in the fluid of which many bacilli are found. Only a few cases have been reported in man, some of these following the injection of musk in the course of typhoid fever, others occurring during the puerperium, and others arising apparently without external injury. It is very probable that some of the conditions reported under this head were not in reality cases of infection by this bacillus. Severe edemas are also seen in human cases of anthrax.

Prognosis.—The consequences of edema vary with the etiology, location, and extent of the process. Collections of fluid in the body cavities may cause compression of important organs, lungs, brain, etc. As a result of edema of the nerves, degenerations and loss of function may take place. Edema of the glottis may cause sudden death from suffocation. Edema of the lungs is very frequently the immediate cause of death in cardiac insufficiency, chronic nephritis, etc. Fatal intracranial pressure may be caused by acute transudation into the cerebral ventricles and submeningeal spaces. Serious interference with respiration and circulation may be produced by pressure upon the lungs or diaphragm by pleural or peritoneal dropsies. In chronic edema marked changes occur in the affected tissues (atrophy, necrosis, inflammation). As the result of the lessened resistance of the edematous part phlegmonous and ulcerative processes are frequent sequelæ to the edema. In general it may be said that the prognosis in edema is serious because of the important pathological conditions underlying its appearance.

Treatment.—In general this is directed to the condition which gives rise to the edema. Extreme distention of edematous skin may be relieved by puncture and continuous drainage. Collections of fluid within the body cavities may also be removed by aspiration.

Aldred Scott Warthin.

**Edema, Angioneurotic.**—See *Angioneurotic Edema.*

**Edema, Malignant.**—Œdema carbunculosum. An edema involving usually the eyelids, lips, neck, or axilla, occurring sometimes as a result of anthrax inoculation. It is frequently accompanied with a vesicular or bullous eruption and the parts affected may be the seat of gangrene. The malignant edema of the lower animals, chiefly guinea-pigs, mice, and rabbits, is caused by the presence of a special microorganism, *B. œdematis maligni*. The larger animals and man are but infrequently susceptible to infection by this bacillus.

T. L. S.

**Edestin** is a crystalline protein occurring in hempseed. It belongs to the group of globulins and as such is readily extracted from ground hempseed by either warm five per cent. sodium chloride solution or cold ten per cent. sodium chloride solution. Upon dialysis of the sodium chloride extract edestin crystallizes in characteristic form.

Frank P. Underhill.

**Education, Medical, in the United States.**—History.—If we were to consider medical education in its broadest sense, we would be obliged to take into account everything that had any effect in the moral,

intellectual, or physical development of aspirants to the medical profession. Such a comprehensive view would include both the formal instruction that is given and the informal training that comes through experience and environment. We shall consider here only the history of the efforts to give formal instruction. This instruction, of course, has been given by the medical profession, whose development in this country we should study if we would rightly appreciate the distinctive features of medical education in the United States. To trace the history of the education of only those who held the degree of Doctor of Medicine in the early days would be to miss entirely the education of a much larger number of men who, though general practitioners of medicine, were not so designated. The general practitioners of two hundred and a hundred and fifty years ago were the "chirurgeons"; they dispensed medicines and drugs, and later took midwifery out of the hands of women. The traditions and customs of these chirurgeons were directly inherited by our medical profession and exert a strong influence on medical education even to this day. Our profession is the result of a gradual merging of university graduates in medicine and of the apprentice-trained: both are represented in our medical educational system, for there are those who support the highest ideals in culture and education and seek to give training of a university character to medical students—that is, to teach the philosophy of every branch of the art and science of medicine; and there are those who desire and give nothing more than rule of thumb instruction. Between these two groups which represent extrêmes are those who desire the fullest instruction with the greatest amount of practical training possible; it is this group which is determining the present character of the instruction given in our best schools. As it is only within recent years that serious attention has been given to medical education by educators in this country, it is interesting to find the causes of this neglect in the history of the development of the American medical profession which is unique.

*Colonial Period.*—The first practitioners to come to the settlements were the surgeons who had been sent over by the colonial companies. At this time in the Mother Country there were two classes of practitioners that had legal recognition—the physicians and the barber-surgeons. The physicians were either licentiates of the College of Physicians which had been founded by the scholarly Thomas Linacre (1460–1524), or they were university graduates. The surgeons and barber-surgeons were the members of an incorporated body and were looked down upon by the physicians because surgery was regarded as vile. These barber-surgeons, "chirurgeons," though not supposed to practise physic, had commenced doing so as early as 1595, for the College of Physicians complained against them on that score at that time. When these surgeons were sent out to the colonies under contract they were always supplied with medicine chests. In the Dutch colony the "chirurgeons" petitioned that none but they be permitted to practise the trade of barber; but they were refused because it was held that the trade of barber was only an adjunct to their profession.

Until just prior to the War of the Revolution there were no medical schools in the colonies. Anyone who wished to attend a medical school had to go to a university in Europe; but only scholars well grounded in the classics could do so because up to the middle of the eighteenth century, the lectures were given in Latin only. Men of such learning were very scarce in the colonies, but the "chirurgeons" were numerous. To become a chirurgeon one had to serve only as an apprentice for a few years. These practitioners increased greatly in number until, with the growth of democratic ways under the new Government they lost their identity and all practitioners were called "Doctor" regardless of whether they held a degree, and all students of medicine served as apprentices whether or not they attended lectures. At the end of the colonial period, it is estimated that there were about 300 men who had been graduated with a degree in medicine, whereas there were more than 3,000 practitioners called either physician or surgeon. Even very early in the colonies the right of the surgeons to prescribe drugs, that is to practise physic, was legally recognized, as is shown by a law passed by the Virginia colony in 1639 requiring "practitioners in physick and chirurgery" to declare upon oath the true value of their drugs and providing means of censure by the court if they neglected or refused assistance to any person in sickness or extremity. In the Massachusetts colony in 1649 and in the Duke of York's grant in 1665 we find, however, a distinction based upon the recognition of guilds or corporations as in England. These two colonies in identical wording provided "that no person or persons whatsoever employed at any time about the bodies of men, women, or children for preservation of life or health as chirurgeons, midwives, physicians, or others, presume to exercise or put forth any act contrary to the known approved Rules of Art in each Mystery and occupation . . . . ." This shows the attitude of the colonists toward medicine which they regarded as a self-governing mystery; this view could only hamper the progress of medical education.

The first recognition of an educational standard for the practice of medicine was given by the colonists of Virginia in 1736 in a law enacted to provide a fee bill for surgeons and apothecaries. The law permitted "those persons who have studied physic in any university, and taken any degree therein," to charge twice as much for every visit and prescription as it permitted such as had only served apprenticeships. That the surgeons practised physic is shown by the provisions in the fee bill as well as by the preamble which is as follows:

"Whereas the practice of physic in this colony is most commonly taken up and followed by surgeons, apothecaries or such as have only served apprenticeships to those trades, who often prove very unskilful in the art of a physician; and yet do demand excessive fees and exact unreasonable prices for their medicine which they administer, and do too often, for the sake of making up long and expensive bills, load their patients with great quantities thereof, than are necessary or useful, concealing all their compositions, as well to prevent the discovery of their practice, as of the true value of what they administer; which is become a grievance, dangerous and intolerable, as well to the poorer sort of people, as others, and doth require the most effectual remedy that the nature of the thing will admit . . . . . "

As the middle of the eighteenth century approached great changes took place. In 1745 Parliament disjoined the corporation which combined the surgeons and barbers. From this time on midwifery largely passed out of the hands of women. In 1746 Cullen at Edinburgh University upset all traditions by audaciously lecturing in English instead of in Latin. A few years later we find men giving lectures and courses of instruction in the colonies. The surgeons who accompanied the British troops to this country for the expedition against the French in Canada were skilful and did much in giving instruction to the colonial surgeons. In 1750 one of the first dissections in this country was performed on the body of a criminal executed at New York City. Dissection of the bodies of any other class was unlawful. Two years later an advertisement by Dr. Wood of New Brunswick, New Jersey, is noteworthy because the same was probably occurring in other colonies. He advertised courses in "osteology, myology, angiology, and neurology" and a course in operations on the dead body. In 1751 the Pennsylvania Hospital

was founded at Philadelphia. The colonies were growing rapidly. Newspapers had been established everywhere and six colleges of Arts had been founded.

The country was not without quacks, however, for Smith in writing of this period in New York City says, "Few physicians amongst us are eminent for their skill. Quacks abound like locusts in Egypt, and too many have recommended themselves to a full practice and profitable subsistence. This is the less to be wondered at, as the profession is under no kind of regulation. Loud as the call is, to our shame be it remembered, we have no law to protect the lives of the king's subjects from the malpractice of pretenders. No candidates are either examined or licensed or even sworn to fair practice." This condition of affairs as described by Smith was not to go on without some effort to check it. In 1760 the first act or law passed in the colonies to regulate the practice of physick and surgery by providing for an examination and licensing of practitioners was passed by the General Assembly of New York, June 10, 1760.

"Whereas many ignorant and unskilful persons in physick and surgery, in order to gain a subsistence, do take upon themselves to administer physick and practise surgery in the city of New York, to the endangering of the lives and limbs of their patients, and many poor ignorant persons inhabiting the said city, who have been persuaded to become their patients, have been great sufferers thereby; for preventing such abuses for the future—

"1. Be it enacted by his honor the lieutenant-governor, the council, and the general assembly, and it is hereby enacted by the authority of the same, that from and after the publication of this act no person whatsoever shall practise as a physician or surgeon in the said city of New York before he shall first have been examined in physick and surgery, and approved of and admitted by one of His Majesty's council, the judges of the supreme court, the King's attorney-general, and the mayor of the city of New York for the time being, or by any three or more of them, taking to their assistance for such examinations such proper person or persons as they in their discretion shall think fit. And if any candidate, after due examination of his learning and skill in physick and surgery as aforesaid, shall be approved and admitted to practice as a physician and surgeon, or both, the said examiners, or any three or more of them, shall give, under their hands and seals, to the person so admitted as aforesaid, a testimonial of his examination and admission."

In 1772 the colony of New Jersey passed a similar law providing that "no person whatsoever shall practise as a physician or surgeon within this colony of New Jersey before he shall first have been examined in physick or surgery, approved of and admitted by any two of the judges of the supreme court for the time being, taking to their assistance for such examination such person or persons as they, in their discretion, shall think fit . . . . ."

At this time the English custom of indenturing apprentices to surgeons, as in trades, held in the colonies. Although the legal form was dropped after the Revolution, the custom was followed well down into the nineteenth century. In the following copy of an interesting indenture, dated August 7, 1760, it may be seen that the practitioner was called "Doctor" and Surgeon, and that he had much to do with drugs and fevers as well as surgery.

"This Indenture made the Seventh day of August, in the Thirty-fourth year of His Majesty's reign George the Second, and in the year of Christ One Thousand Seven Hundred and Sixty, Witnesseth that Jacobus Hubbard Son of James Hubbard of Gravesend on Nassau Island and Province of New York, Farmer, hath put himself and by these presents doth voluntarily and of his own free will and accord and by and with the consent of his Father and Mother put himself as an Apprentice unto William Clark of Freehold in Monmouth Co. in East New Jerseys Doctor and Surgeon, to be taught in the said practice of a Doctor and Surgeon, and in all the several branches of Physic which the said William Clark practises within the said town herein mentioned: and with him to live after the manner of such an Apprentice to continue and serve from the day of the date hereof unto the full end of Four Years and Eight Months from thence next ensuing and fully to be completed and ended. During all of which Term the said Apprentice his said Master well and faithfully shall serve, his secrets keep, his lawful commands gladly everywhere obey. He shall do no damage to his said Master nor see it to be done by others without letting or giving notice to his said Master. He shall not contract matrimony within the said term. At cards, dice or any other unlawful game he shall not play, whereby his said Master may have Damage. He shall not absent himself day or night from his said Master's Service without his leave, not haunt Ale houses, Taverns or play houses, but in all things as a faithful Apprentice he shall behave himself toward his said Master all during his said term. And the Said Master during the said term shall by the best of his Means or Methods Arts and Mysterys of a Physician and Surgeon as he now professes Teach or cause the said Apprentice to be Taught to perfection in consideration of the sum of One Hundred Pounds Lawful money of New York to him in hand paid by the said James Hubbard (in four payments) that is to say Thirty Pounds in hand down, and the remainder in Four Equal payments. One each year till the whole is paid. And the said William Clark Acknowledges himself therewith contented and the Receipt thereof. And the said Master is to provide his said Apprentice with sufficient Meat Drink Washing and Lodging and Mending his said clothes within the Said term. And the said James Hubbard is to find him in wearing apparel during said term aforesaid. At the end of Said term the Said Master shall and will give unto the said Apprentice a new set of surgeon's pocket instruments—Soloman's Dispensatory, Quences Dispensatory and Fuller on Fevers, and for the true performance of all and every of the said covenants and agreements of Either of the said parties Do bind themselves Jointly and Severally to the other by these presents. In witness whereof they have hereunto set their hands and Seals the Day and Date first written."

In 1765 the medical department of the College of Philadelphia was founded and a year later clinical instruction at the Pennsylvania Hospital was begun. The founding of this the first medical school in the colonies deserves careful attention. It was due to the zeal of Drs. John Morgan and William Shippen, Jr. The former had been graduated in Arts by the College of Philadelphia, and had studied medicine as an apprentice; while serving as surgeon in the French and Indian War he had found that his training did not measure up to that of the foreign-trained surgeons. He thereupon resigned and went to Europe where he studied five years under the most celebrated masters of his time and became thoroughly acquainted with every science that related in any way to the duty of a physician. He was graduated a Doctor of Medicine by Edinburgh University. While in Europe he worked out all the details of the curriculum for the medical school which he later helped to found. He talked over his plans with great teachers in the universities as well as celebrated independent teachers like the Hunters.

William Shippen, Jr., who had quite as much to do with the establishment of this first medical school in the colonies, was likewise well educated. He had been graduated from the College of New Jersey (Princeton) and after studying medicine with his father had gone

to Edinburgh where he was graduated in medicine by the University. He, too, spent five years studying under the Hunters and others equally famous as teachers. He returned to Philadelphia and three years later Morgan came to help him organize the medical department. For many years these two men controlled the policies of the new school. It followed the university custom of granting only the Bachelor's degree upon the successful completion of the prescribed courses, and of withholding the Doctor's degree until after three years of approved work.

The entrance requirements and the curriculum of the first school founded in this country are of interest. For matriculation it required that the candidate should show efficiency in the natural sciences and in Latin. It stipulated that the candidate should attend at least one course of lectures in anatomy, materia medica, chemistry, the theory and practice of physic, one course of clinical lectures, and should attend the practice of the Pennsylvania Hospital for one year. After the completion of these courses the candidate could be admitted to the examination for the Bachelor's degree. It also required that he should serve an apprenticeship with some physician. For the Doctor's degree the candidate had to wait three years and then write and defend his thesis.

The only medical society that has survived and which is known to have preserved records and transactions that antedate the Revolution, is the New Jersey Medical Society which was organized in 1766. The desire of this medical society to elevate the standard of medical education is evident from one of the very first rules adopted, "The apprentice must be refused unless he has a competent knowledge of Latin and the rudiments of Greek and will serve not less than four years, one of which must be spent abroad, and pay 100 pounds as apprentice fee." In the charters of the first medical societies organized after the Revolution it is shown that they were much concerned about educational problems. Apprentices and students were recommended to attend medical lectures that "quackery might be banished from the land." They sought knowledge how to preserve "a sound mind in a sound body." These early medical societies played an important part in educational work. When the society met there was an interchange of experiences and knowledge that meant a great deal to most of the members who lived in more or less isolated places. Later when the State medical societies were organized they were given control of the regulation of medical education. The great majority of the members being apprentice-trained did not abolish this system in favor of the medical colleges which had been established in connection with Philadelphia College (University of Pennsylvania) in 1765, King's College (Columbia) in 1767, and the University of Cambridge (Harvard) in 1783. There were many other factors which prevented the rapid adoption of the American medical college, but it should not be lost sight of that apprentice-trained practitioners controlled the situation of medical education in the States. By act of legislature, Massachusetts in 1781 incorporated the Massachusetts Medical Society. The Society was authorized to appoint a board of censors, whose duty it was to examine all candidates for admission into the profession and to grant licenses to such as were found qualified. Connecticut, New Hampshire, New Jersey, and Maryland passed similar laws in the eighteenth century.

In the thirty years from 1769 to 1799 there were but 221 men graduated by the American medical colleges, University of Pennsylvania (1765), Columbia (1767), Harvard (1783), and Dartmouth (1797), these four being all that were established by the end of the eighteenth century.

*Nineteenth Century.*—Medical education had been given a good start in colonial days with high standards but later it underwent a change because it was retarded by the war and could not resist the demand for low-standard schools due to the influence of the apprentice-trained. Under the new political conditions respect for authority and old traditions became less and less.

The school at Philadelphia had had its political troubles, the property had been confiscated and turned over to the University of Pennsylvania and in the reorganization of the school the high standard of scholarship and requirements in preliminary education were abandoned; and the school which had been established in connection with King's College (Columbia) had had its progress hampered by the British occupation of New York City, and by the dissensions in its faculty over political opinions. This school in New York had graduated only thirty-seven students by the beginning of the nineteenth century. The curriculum and the requirements for the Bachelor's and Doctor's degrees were patterned after the University of Edinburgh; the New York Hospital had been founded by the same men that established the school; yet for some reason the school was not popular. That one organized on different lines was desired is evident from the petition of the New York County Medical Society which finally, after sixteen or more years of effort, in 1807 succeeded in obtaining a charter for its College of Physicians and Surgeons. It obtained a grant of $20,000 from the legislature which at that time conducted a "literature fund lottery" for the purpose of raising money for colleges, and in 1814 it took in the faculty of the medical school affiliated with Columbia (King's) and was allotted $10,000 additional. Later the control passed from the County Medical Society to a Board of Trustees and finally in its later history it became the medical department of Columbia University. This is not the only school that received aid from the State; in 1812 the College of Physicians and Surgeons of the Western District of the State of New York was incorporated and given $15,000 to be paid from the lottery, and as late as 1844 the State Legislature helped other medical schools. Later than this the regular profession came into conflict with practitioners of "new schools," the Botanics, the Thomsonians, the Eclectics, and the Homeopathists, and through this antagonism there was brought to an end the grants of money by which the State had aided medical colleges.

After 1812 the medical schools had discontinued granting the Bachelor's degree and all graduated their students as Doctors. From this time the general custom of calling every practitioner "Doctor," whether he had been graduated or had served only as an apprentice, became established. The great majority of all practitioners throughout the States were apprentice-trained, and they controlled the licensing privilege in most of the States. In New York in 1806 the authority to license and examine physicians and surgeons had been taken away from the State officials and the courts by the enactment of a law similar to those which had been passed in Massachusetts and other States. The law authorized legally qualified physicians and surgeons of each county to form themselves into a society, named after the county in which it was formed, and to appoint a board of censors to examine and license all applicants for admission into the profession in their respective counties; but no one could be admitted to an examination until he had given evidence of having studied three years with some practitioner, and had arrived at the age of twenty-one years.

Although one did not have to attend a medical school to get a license, schools sprang up in all parts of the country.

The following is a list of the medical schools that had been established by 1826 with the number of students enrolled for the year 1825–6.

| | Year. | No. students. |
|---|---|---|
| University of Pennsylvania | 1765 | 480 |
| Med. School of New York | 1768 | 196 |
| Med. School of Harvard College | 1782 | 130 |
| Med. School of Dartmouth College | 1798 | 80 |
| College of Med. of Maryland | 1807 | 215 |
| College of Physicians and Surgeons of the Western District of N. Y. | 1812 | 120 |
| Med. School of Yale College | 1813 | 82 |
| Med. College of Ohio | 1818 | 22 |
| Vermont Academy of Med | 1818 | 124 |
| Med. School of Transylvania | 1819 | 235 |
| Med. School of Maine | 1820 | 60 |
| Med. School of Brown University | 1821 | 40 |
| Med. School of the University of Vermont | 1822 | 42 |
| Berkshire Med. School | 1822 | 94 |
| Med. College of S. Carolina | 1824 | 50 |
| Med. School of Jefferson College | 1824 | |
| Columbia College in the District of Columbia. | 1824 | |
| Med. School of Auburn | 1825 | |
| Med. School of the Valley of Virginia | 1826 | |
| Rutgers Med. College | 1826 | 153 |

According to Thacher, writing in 1828, 8,000 men had received instruction within the walls of the Philadelphia Medical College since its first establishment sixty-two years before and "from this source the remotest parts of our Universe had been furnished with learned physicians who are ornaments to their profession."

In 1829 the Reformed Medical Society of the United States was organized and two years later opened the Reformed Medical School at Worthington, O. This society and school were made up of men who opposed the educational requirements of most State medical societies which at this time controlled medical education through laws which had placed the authority to examine and license candidates for the privilege of practising medicine, in the medical societies' boards of censors. In 1833 Indiana granted a charter for the "University of Indiana" to John C. Bennett who immediately commenced the sale of medical diplomas. This was one of the first "diploma mills." The year previously in New York fifteen physicians had been elected to the legislature on account of the cholera epidemic and this year fifteen more were elected—making a total of thirty physicians in the New York State legislature. They passed a law raising the requirements for license to practise and making it impossible for illegal practitioners to sue for payment of accounts. Good laws for the regulation of the practice of medicine were passed in most of the other States also at this period. By 1844 all of the irregular practitioners were organized, and the Eclectic-Botanic, Thomsonian, Reformed, and Homeopathic organizations were having the medical laws throughout the States amended so as to permit them to practise. It was in 1844 that the American Institute of Homeopathy, the national association of *bona fide* homeopathic practitioners, was organized. It was at this time that the regular medical profession prepared to organize on a national basis to fight the abuses of the licensing privilege which had arisen within their own ranks. Medical schools through controlling the local county board of censors could guarantee the right to practise to the holders of their diplomas and some of these schools were more anxious to sell diplomas than to uphold educational requirements.

In 1839 the Medical Society of the State of New York passed the following resolution

Resolved, That the right of teaching ought to be separated as much as possible from the power of conferring degrees or license.

The following year in the report of the committee on medical education we find this:

"But in view of the diploma being depreciated by the rapid establishment of new schools, it may well become a question deserving serious consideration whether, at no distant period, the right of teaching and licensing should not be disjoined. An incidental difficulty to the adoption of this suggestion is the fact that we are surrounded by institutions in other States which might or might not follow it, and thus our students be induced to desert our own colleges."

This same subject was continued in later annual meetings and resulted in a call being issued by the Society for a convention of delegates from all the medical colleges and societies in the United States. This convention was held in New York, in May, 1846, and from it originated the American Medical Association. In 1845 the first homeopathic college, the North American Academy of Homeopathic Medicine, was opened at Allentown, Pennsylvania. At this institution the instruction was given in German. Three years later the Homeopathic Medical College of Pennsylvania was opened at Philadelphia. The Homeopathists were somewhat divided at this time over Rau's Organon of Specific Homeopathy. Rau's ideas later found expression in some of the theories of the present Eclectic school. In 1845 the Eclectic Medical Institute of Cincinnati was founded by the same individuals who had previously founded the Reformed Medical School at Worthington, O.

In 1848 the Female Medical Educational Society was formed to organize a Woman's Medical School. Elizabeth Blackwell had succeeded in being admitted to the Medical Institute at Geneva, N. Y., but after her admittance the Faculty voted not to admit any more women. She was the first woman to be graduated in medicine and in 1857 she and her sister Emily succeeded in getting the Quakers of New York to establish the New York Infirmary for Women and Children for the purpose of training both nurses and women physicians. In 1861 Dr. Elizabeth was in England and in intimate relation with Miss Florence Nightingale. Upon her return she was instrumental in founding the Relief Association and later was active in other organizations that bore an important part in the development of nursing in this country. In 1899, forty years later, the excellent school which they had established for women physicians voluntarily closed. At this time Dr. Emily Blackwell at the closing exercises said "The necessity for coeducation in some form becomes more evident the higher the character of the education. You may establish separate schools for boys and girls but as the schools grow to colleges, and the colleges to universities it becomes evident that this grand and costly system cannot be duplicated, that women's education can only reach this highest level in connection with these great centers. In no department is this more true than in that of medicine. Medical education has made immense advances in the last thirty years. The modern school with its broad and long course of study, its army of teachers of all grades, its costly laboratories for scientific training, its systematic clinical instruction and hospital classes is an utterly different institution from the small comparatively inexpensive college of thirty years ago."

The civil war meant much to medical education in the training it afforded a large number of physicians and surgeons in the large hospitals that were set up. The general introduction of anesthetics greatly increased the extent of surgery and consequently the number of hospitals. It was in the period following the civil war that service in hospitals as internes became highly prized and was sought by large numbers of medical students through competitive examination. These students in preparing for the competitive examination worked hard and went far beyond the requirements of the colleges. It would be a great mistake to assume that there were but few good students in those days simply because the statu-

tory and college standards were very low. It is only in recent times since great numbers of good hospitals have been established, affording numerous opportunities for interneship, that there has been a letting up in the competition and hard work necessary to obtain such an appointment. However, we are making a general survey of the condition of medical education and it cannot be said that the great number of schools established in the 70's and 80's kept pace with the rapid development of medical science. In 1870 there were eighty medical schools in the country and all supported by students' fees. The teaching was by lectures only, and these for the most part about things which the student never saw. There was no laboratory instruction to train the student and dissection was not obligatory. The same lectures were repeated each year, but the student was required to attend two years and pay fees twice for the very same lectures before he could appear before the faculty for an oral examination. If a majority of the faculty voted in his favor he was given his diploma. Harvard was the first university to reclaim its medical department and to set about to correct the low standard of medical education. It began in 1871 by providing for a three-year graded course of instruction.

The hospitals commenced to improve in the 70's because of the influence of trained nurses. In 1873 the Woman's Education Association brought about the establishment, on modern lines, of a training school for nurses in the Massachusetts General Hospital, and this was soon followed by the establishment of similar schools in the Pennsylvania and Bellevue Hospitals. Though improvement had begun in some of the older and larger medical schools at this time it is not true that this improvement was at all general. Even at the present time there are schools which afford no training other than that of the drill master with a text-book. In 1873 the Alumni Association of the College of Physicians and Surgeons of New York City was incorporated to promote the interest of the College in medical education. A committee reported that there was "no more certain way of advancing the standard of medical education than by furnishing the most ample facilities for the prosecution of studies and investigations in the purely scientific departments of medicine." By 1877 it had raised $10,000 from the alumni and with the assistance of Dr. Francis Delafield opened the first pathological laboratory in an American medical school.

The first large sum of money given for the purpose of a medical school was in 1884. Mr. William Henry Vanderbilt, the oldest son of Commodore Vanderbilt, gave a half million dollars to the College of Physicians and Surgeons in New York City. The sum was so large that the College had to have its charter amended by special act of the legislature to enable it to legally receive the gift. Members of his family soon after established the first maternity hospital and a general clinic devoted to teaching purposes.

Near the end of the century all of the universities were striving to put their medical departments on a higher plane by increasing the entrance requirements, by extending the laboratory and clinical facilities, and by giving more attention to methods of instruction. State boards of medical examiners nominated by the respective State medical societies had supplanted the county boards of censors, and public opinion and the influence of the better part of the profession had practically made it obligatory to have been graduated from a medical school to obtain a license. The old laws which required a medical student to serve under a preceptor for three or four years even though he had attended lectures were gradually repealed, and brought about an end to the apprentice system. To hold a medical diploma was all that was necessary to obtain a license. This caused more sham schools to spring up. Some of the statutes simply stated that the applicant for a license must hold a diploma from a "reputable college." Attention became centered on the medical schools and it was not long before there was a movement to make them conform to a definite standard. Dr. John H. Rauch of the Illinois State Board of Health was the first to collect data on American medical colleges; this was late in the 80's. The National Confederation of State Examining and Licensing Boards in 1890 began holding conferences with a view to establishing uniform legislation and to bringing about a uniform standard of medical education and examination throughout the States. At about the same time the Association of American Medical Colleges was organized to work along similar lines. At the end of the century there were 155 medical colleges and all but fourteen had adopted a four-year graded course. Graded courses of instruction had been introduced into the better schools in the early 70's. Examination in each topic supplanted the general oral examination by the entire faculty which was the custom when the medical course consisted of lectures only. The better schools found it necessary to have some instructors who devoted their whole time to teaching and laboratory work. Especially was this true in the laboratory branches, anatomy, physiology, chemistry, and pathology; but at first there was nothing general as to which professors should devote all of their time to laboratory teaching. As the laboratory courses in histology, pathology, and bacteriology grew in length with the rapid increase of knowledge in these branches of science it soon led to a lengthening of the college curriculum as is shown by the following table:

TABLE TO SHOW THE NUMBER OF COLLEGES WITH THE ONE-YEAR, TWO-YEAR, THREE-YEAR, AND FOUR-YEAR GRADED MEDICAL COURSES FROM 1876 TO 1914.

| Year | Four-year course. | Three-year course. | Two-year course. | One-year course. |
|---|---|---|---|---|
| 1875 | 0 | 3 | 72 | 5 |
| 1885 | 0 | 5 | 103 | 0 |
| 1897 | 99 | 49 | 0 | 2 |
| 1898 | 103 | 42 | 0 | 0 |
| 1899 | 141 | 10 | 2 | 2 |
| 1914 | 106 | 0 | 0 | 0 |

At the close of the century the 155 medical schools were turning out "Doctors" at the rate of 4,000 per year. In 1897 fourteen medical schools had some endowment funds and these totaled only $648,262. Within a year the endowments of these schools and five additional ones amounted to $1,906,072. Medical education was still dependent upon students' fees.

*Twentieth Century.*—At present there are only two State boards of medical examiners, Massachusetts and Tennessee, which do not require graduation by a medical college as an essential for admission to the licensing examination. The Massachusetts State Board holds oral and practical examinations in connection with the regular written one. All but fifteen of the States have laws which provide that the applicants for license to practise medicine shall give evidence of having had a general education equivalent to an ordinary high school course before beginning the required four-year medical course.

Lack of uniformity in educational standards and unevenness in the administration of State boards prevent the States from generally indorsing one another's licenses. But this condition is improving since colleges and boards have adopted means of measuring education, that is evaluating credentials. This work is recent. The National Confederation of State Medical Examining and Licensing Boards thoroughly investigated the curricula of the American medical colleges and found a lamentable want of

uniformity in the length and character of the medical courses in the various colleges. It thereupon adopted a standard of 3,600 hours of work as a minimum for a medical college and specified the relative time and importance of each subject. This work was followed up by the American Medical Association in establishing its Council on Medical Education which is a committee authorized to investigate medical education in this country and to publish its findings. Since 1905, annual conferences have been held on medical education under the auspices of this Council. Through its Secretary, Dr. N. P. Colwell, it has carefully collated data on every medical school and state board in the Union, and by a system of scoring has classified all the medical schools according to four grades, A+, A, B, C. The points considered are the showing of the graduates before state boards, the enforcement of the preliminary requirements, the character of the institution, laboratory equipment, and clinical facilities.

In 1910 the Carnegie Foundation for the Advancement of Teaching published Mr. Abraham Flexner's very valuable report on medical education in the United States and Canada. The report is a comprehensive study of medical education in this country based upon personal inspections of all the medical schools. The publication of this report gave renewed impetus to the work of the several Associations of Medical Colleges, the two confederations of State medical boards, and the American Medical Association's Council on Medical Education, with the result that at present seventy-seven of the 105 medical colleges require at least one year of work in a college of liberal arts before admission; a critical study of previous conditions had shown that too much of the medical student's time was spent upon the necessary preliminary sciences, physics, chemistry, and biology, which do not properly belong in the medical school curriculum, to the sacrifice of important clinical training. These progressive colleges are being backed up by thirteen State licensing boards which have adopted similar requirements for the preliminary education of all applicants.

*Preliminary Requirements.*—Names do not always mean the same in different parts of the country. Definitions become necessary. What may be regarded as a high school in one section may be called an intermediary grammar school in another. The United States Bureau of Education has come to the rescue in this matter by publishing a list of accredited schools in the United States. The inspection and rating were done by some State authority or by some of the institutions which are mentioned below as being parties to the definition of the term "unit."

An "accredited secondary school" is a secondary school which requires for graduation at least fifteen units of secondary work above a standard eight-grade grammar-school course and which has been investigated and approved by a State department of education or other reliable authority. Some variation from this definition has been accepted in the case of the Southern States, whose high schools are organized for the most part upon the seven-year elementary course as a basis. The following authoritative definition of the word "unit" has been made by the National Conference Committee on Standards of Colleges and Secondary Schools, which is made up of representatives of the National Association of State Universities, the New England College Entrance Certificate Board, the College Entrance Examination Board, the Association of Colleges and Preparatory Schools of the Middle States and Maryland, the North Central Association of Colleges and Secondary Schools, the Association of Colleges and Preparatory Schools of the Southern States, the New England Association of Colleges and Preparatory Schools, the Carnegie Foundation for the Advancement of Teaching, and the United States Commissioner of Education.

A unit represents a year's study in any subject in a secondary school, constituting approximately a quarter of a full year's work.

It should be noted in this connection that there is a wide range in the subjects which may be offered in fulfillment of the fifteen units prescribed for the schools in different States. The subjects recognized by the College Entrance Examination Board as permissible in the standard high-school course are briefly:

| | Units. |
|---|---|
| English up to | 3 |
| Mathematics up to | 3½ |
| Latin | 4 |
| Greek | 3 |
| French | 3 |
| German | 3 |
| Spanish | 2 |
| History | 4 |
| Science | 4 |
| Drawing | 1 |
| Music | 2 |

*College Work required for Admission.*—More than three-fourths of the medical colleges require college work in physics, chemistry, biology, and a modern language. The time allotted to each which is acceptable to most medical colleges is a total of 192 class hours for each of the laboratory subjects and about 128 hours for the language.

There are now thirty-one medical schools which require as a minimum for entrance, two or more years of work in a recognized college of liberal arts in addition to a four-year high-school education.

*Medical School Curricula.*—Quite a number of the State boards have prescribed a minimum course of study which must be given by medical colleges before they can be approved by the board. The specifications are quite elaborate in some instances and are subject to frequent change. These specifications are necessary as a legal basis for the refusal to recognize inferior colleges—those that are not "reputable." The specified curriculum is not meant to hamper the better schools. For this reason, only a minimum course is specified. In such specifying by a State there is the danger of mechanizing education and bringing all schools to a dead level of mediocrity. Some State boards recognize schools, only of class A+ or A of the American Medical Association's list. Others, like New York, have their own lists. The New York State Education Department (University of the State of New York) at present recognizes the diplomas of sixty-six medical schools in the United States. The Pennsylvania Bureau of Medical Education and Licensure finds seventy-six medical colleges acceptable, the Ohio State Medical Board sixty-three, and the American Medical Association seventy-five. It is only the university medical schools in large cities, in America, that have sufficient clinical facilities and pathological material.

*Cost.*—At present there is $27,222,950 invested in real estate and buildings used for the purpose of medical education. There are endowment funds amounting to more than $15,000,000. In the year 1912 the income of medical colleges from other sources than students' fees amounted to $1,743,447 and that from students' fees alone to $4,528,845, making a total income of $6,272,492. This sum was expended directly or indirectly for the benefit of 18,452 medical students; the expenditure per capita being $339. The teaching force for these students consists of 7,572 professors and instructors, many of whom serve without pay. The lowest tuition fees are charged by the medical departments of the State universities, of which there are eighteen.

*Number of Students.*—During the year 1913, 17,015 students were enrolled: 15,919 in regular medical colleges, 850 in Homeopathic colleges, and 256 in Eclectic colleges.

*Women.*—Fifty-five of the 105 medical schools are coeducational. In 1913 there were 640 women students. There are but two women's medical colleges.

NUMBER GRADUATED BY MEDICAL SCHOOLS IN THE UNITED STATES DURING EACH PERIOD OF TEN YEARS FROM 1769 TO 1899 AND DURING EACH YEAR FROM 1900 TO THE PRESENT.

| Years. | No. of graduates. | Years | No. of graduates. |
|---|---|---|---|
| 1769–1799 | 221 | 1901 | 5,444 |
| 1800–1809 | 343 | 1902 | 5,009 |
| 1810–1819 | 1,375 | 1903 | 5,698 |
| 1820–1829 | 4,338 | 1904 | 5,747 |
| 1830–1839 | 6,849 | 1905 | 5,600 |
| 1840–1849 | 11,828 | 1906 | 5,364 |
| 1850–1859 | 17,213 | 1907 | 4,980 |
| 1860–1869 | 16,717 | 1908 | 4,741 |
| 1870–1879 | 23,966 | 1909 | 4,515 |
| 1880–1889 | 30,847 | 1910 | 4,440 |
| 1890–1899 | 40,284 | 1911 | 4,273 |
| 1900 | 5,214 | 1912 | 4,483 |
| | | 1913 | 3,981 |

*Present Aims.*—A few years ago President Eliot of Harvard remarked "If I were asked what branch of education the greatest improvements have been wrought in during the last thirty-five years, I would say without a moment's hesitation that it is in medical education." The most of this improvement is as we know a result of the great strides in medical science following Pasteur's and Lister's work and the general development of scientific knowledge in every branch. However, it is not entirely due to this alone. Medical education had been sadly neglected. President Eliot recalled fifty years ago when the Harvard Medical School had no examination for admission and no standard of preliminary education, when "anybody could walk into it from the street and many did walk into it who could barely read and write." There was great room for improvement in any branch of medical education that had fallen so far from its true position. To-day all of this is changing. Yet there are still some medical schools which, although on paper they seem to be up to a certain standard, are really very inferior. The present aim is to drive out all these base schools and to see to it that every student desiring a medical education gets what he should have. That he may properly profit by his medical studies and not consume his own time and that of his instructor it is planned by the best schools that he should come to his medical studies well grounded in physics, chemistry, zoology, and botany. It is also planned that he should have a reading knowledge of one of the modern languages, preferably German, so that he may be able to read other than English scientific papers. The medical course is designed to be as practical as possible and rounded out with an abundance of bedside instruction. This calls for a greater correlation of the work in the medical colleges than previously when all of the student's pathological work was quite separate and apart from any of his clinical work, when he saw "cases" of pneumonia, typhoid fever, Pott's disease, Colles' fracture, otitis media, etc., instead of studying and observing patients throughout their entire illness.

Medicine in America is undergoing a wholesome revolution. Within a few more years a new generation will be at the helm and although they may never excel their forerunners in practical sagacity and accomplishment, still it is expected that some truly great centers of medical education will be developed here as in Europe. Some of the foreign centers are favored by an abundance of clinical and pathological material; we may hope for the same when an enlightened profession guides public opinion. With 91,972,266 inhabitants and 142,190 physicians, that is one physician to every 640 persons, and more medical schools than all the rest of the world, it may seem discouraging, but it should not when we consider the distinctive features of American life. We have no great ignorant peasant class, most of our inhabitants are leading very active lives and are employing their own physicians—not lodge physicians. The ratio of physician to population is not discouraging. In any group of 600 people there is more than enough to keep a good careful studious physician busy; there are hundreds of conditions that could be prevented or improved in such a small group if the physician were well trained. We can prove this by looking at the surgeon's journal on any man o'war where, even though all have been previously selected for their physical fitness, enough become ill or injured to tax a well-trained physician's ability. We should rejoice that there are so many physicians in our land but regret that many are so poorly trained.

OTTO V. HUFFMAN.

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**Egg, Yolk of.**—See *Vitellus Ovi.*

**Egypt.**—This country, embracing the valley of the Nile and a portion of the desert, long known as a winter sanitarium, illustrates the dry warm desert climate, resembling that of Arizona, New Mexico, and portions of Texas and California in the United States. The main characteristics of the climate are: (1) *Warmth*, the mean temperature of Cairo for the winter months being 58.3° F. (2) *Large diurnal variation*, the difference between day and night temperatures varying from 35° to 19° F. (3) *Dryness of atmosphere* and *small rainfall.* "Six rainy days only in five months were chronicled at Assouan in 1892–93." The difference between the wet and dry bulbs sometimes amounts to 24° F., and the annual relative humidity varies from 58.4 per cent. at Cairo to 45 per cent. at Luxor. (4) Almost *continuous sunshine.* (5) Great *purity of the desert air.* "Meat exposed to the air becomes mummified in three weeks without any trace of decomposition." The general effect of this climate upon the individual is bracing, and at the same time sedative to the nervous system.

The resorts generally frequented by invalids, especially by the tuberculous, are Gizeh (The Mena House), Helouan, Luxor, and Assouan. There should also be mentioned the Nile voyage and camping out. Cairo is to be avoided by the invalid for any lengthy stay, for no large crowded city, even if it possesses the best possible climate, is to be recommended to an invalid, and further, the sanitary condition of Cairo is not good, and the portion occupied by the European settlement is built upon what was once a swamp and is still in parts swampy. "Moreover, the country around Cairo is most thoroughly irrigated, and the exhalations from the moist land after sunset are extraordinary." (Solly, "Medical Climatology.") Since the occupation of Egypt by the English, everything has been established upon a more orderly and stable basis, and doubtless the influence of this is felt, even in the health resorts, in greater attention to the sanitary conditions. The season for visitors extends from October or November to the first or middle of April. Before considering in detail the resorts mentioned and the other means of utilizing the climate, it will be well to discuss the climatic elements, their advantages as well as disadvantages, and for this purpose the following simple chart has been compiled from various sources:

Climate of Egypt. Observations Mostly Taken at Cairo.

| Data. | October. | November. | December. | January. | February. | March. | For year. |
|---|---|---|---|---|---|---|---|
| Temperature (Fahr.)– | | | | | | | |
| Average or normal. | 74.3° | 64.4° | 58.4° | 53.6° | 57.0° | 62.8° | 70.2° |
| Average daily range | 19.2 | 17.9 | 17.3 | 14.8 | 16.5 | 20.2 | 19.7 |
| Mean of warmest.. | 84.0 | 74.2 | 67.7 | 61.4 | 65.3 | 73.2 | 80.1 |
| Mean of coldest ... | 64.8 | 56.3 | 50.4 | 46.6 | 48.8 | 53.0 | 60.4 |
| Highest or maximum..... | During 1888 the absolute maximum reached was 111.8° on July 13 In 1887 it was 110° on June 9 | | | | | | |
| Lowest or minimum..... | In 1888, the absolute minimum was 36.4° in January. In 1887 it was 35.2° in January. | | | | | | |
| Humidity— | | | | | | | |
| Average relative... | 65.8% | 67.5% | 69.6% | 69.7% | 66.2% | 56.2% | 58.4% |
| Average absolute.. | .52 | .39 | .33 | .28 | .29 | .29 | .40 |
| Precipitation— | | | | | | | |
| Average in inches.. | .... | .21 | .19 | .19 | .24 | .03 | 1.22 |
| Wind— | | | | | | | |
| Prevailing direction ..... | N. | N. | N. | S.W. | N. | N. | N. |
| Average hourly velocity..... | 3.2 | 2.1 | 2.2 | 2.2 | 1.4 | 2.5 | 2.9 |
| Weather— | | | | | | | |
| Clouds (0–10) .... | 2.5 | 3.0 | 3.7 | 4.1 | 4.2 | 3.4 | 2.6 |

"In a total of 1,083 observations made during the course of three years, the sky at Cairo was found to be cloudless 709 times; clouds were obtained 254 times, an overcast sky was seen 95 times, and a truly cloud-covered sky was recorded on only 25 occasions." (Lombard, quoted by Richards.)

In the desert and at Luxor clouds are almost unknown. At Cairo, during the winter months, there are only from twelve to fifteen days upon which rain falls. At Luxor rain is a very rare phenomenon. During five months at Assouan, in the winter of 1892–93, there was blue sky on all but fifteen days.

The most remarkable feature of the Egyptian climate is considered to be the peculiar dryness of the atmosphere, rendering the air bracing and tonic. The relative humidity at Cairo for the year is 58.46 per cent., and for the seven winter months it averages 63.25 per cent. At Gizeh and Helouan it is considerably lower, and still more so at Luxor and Assouan, it being 50.5 per cent. at Luxor.

There is almost complete absence of rain. At Cairo the annual rainfall is 1.22 inches, and the number of rainy days during the winter season (seven months) is twelve. At Luxor there usually is no rain.

Unless it be in southern and southwestern Arizona, no portion of the United States can be compared with

Egypt in the matter of cloudlessness of sky; and it is hardly necessary to add that no such freedom from clouds exists in any part of Europe. This circumstance, taken in connection with the mildness of its day temperature, even in mid-winter, and the comparatively long duration of the hours of possible sunlight (depending upon its southern latitude), marks the whole country of Egypt, and particularly its more southern portion, as that region of the world affording perhaps the best facilities to the invalid desiring to pass as much time as possible in the open air during the cold season of the year. The hours of possible sunshine are much longer in Egypt than in Davos or the Engadine, longer than in Colorado, and even longer than in Southern Arizona; the intensity of the sunlight, especially in Upper Egypt, is probably as great as at any of these places (although we have no data at hand to prove that such is the case); the purity of the atmosphere in respect to the presence of germs, outside of the towns, is probably not far inferior, even in the Nile valley, to that of Colorado, Davos, or Arizona; while in the desert proper it is quite as great. The temperature during the day is higher without being, as a rule, excessive; while by night it is also higher, and, although abundantly cool to be invigorating, is, nevertheless, not more contrasted with the day temperature than is the case in Arizona, Colorado, or Davos. Rain is less frequent than at Davos or in Colorado, and is as infrequent as in Southern Arizona, even at Cairo; and, owing to the absence of clouds, the actual number of hours of sunshine coincides more nearly with the possible number of such hours than is the case in Colorado, Davos, or Arizona. Winds in Egypt are of more frequent occurrence than at Davos during the winter, but probably no more so than in Colorado or in Arizona; while in point of velocity they are probably not higher than in Colorado, although higher than at Davos, and perhaps higher than in Arizona. Absence of statistics prevents an accurate comparison of these resorts in this respect. Violent hot winds, laden with sand from the desert, and exerting a very debilitating influence not only upon men, but also upon animals, occasionally blow in Egypt during the latter part of the winter season. These winds come from the south, and seldom begin to blow before the middle of February; indeed, their time of most frequent occurrence is during a period of fifty days after the vernal equinox, to which circumstance they owe their name, Kamsin. The kamsin blows, on the average, at Cairo only upon eleven days out of the whole year. The rapid and extreme rise of temperature produced by one of these winds, occurring on May 31, 1857, is instanced by Dr. Hann on page 443 of his "Handbuch der Klimatologie." The drying effect of the wind is also shown in the figures quoted by Dr. Hann, which figures are given below.

Kamsin of May 31, 1857, at Cairo.

| Hour. | Temperature. | Relative humidity. | Wind. |
|---|---|---|---|
| 7 A.M. | 78.08 | 54 | Calm. |
| 10:30 A.M. | 100.76 | 19 | S.S.W.[2] |
| Noon | 103.64 | 12 | S.S.W.[2] |
| 2 P.M. | 105.62 | 15 | S.S.W.[3] |
| 9 P.M. | 95.18 | 13 | Calm. |
| 11 P.M. | 91.4 | 19 | Calm. |

The small figures appended to the letters S.S.W., showing the direction of the wind, probably indicate the velocity *in meters per second*, a velocity which would be equivalent to 4.47 miles per hour at the hours of 10:30 A. M. and noon, and to 6.71 miles per hour at 2 P. M. Even if these figures are intended to mark the velocity of the wind according to the scale in which 0 represents a calm and 10 a violent hurricane, it is evident that the force of this particular kamsin wind was not particularly great. At Cairo, the prevailing direction of the wind during the months of January, February, March, and April is stated by Dr. Kisch (Eulenburg's "Real-Encyclopädie") to be as follows: January, northeast; February, northwest; March, west; April, north. Of the winds at Cairo, Dr. Rotureau ("Dictionnaire Encyclopédique des Sciences Médicales") speaks as follows: "The east wind is almost the only one which blows at Cairo during the months of January and February; it lasts from ten o'clock in the forenoon until sunset, and it is against its freshness, often very considerable, that invalids walking out of doors should especially protect themselves. When the east wind is violent, it is almost impossible to go out of doors on account of the clouds of dust which it raises, and which it causes to penetrate even into the most tightly closed apartments. Such a violent easterly wind, however, seldom occurs at Cairo on more than six or eight days out of the whole year. Winds from the northeast, north and northwest sometimes blow, but never last long enough to be dangerous (n'existent jamais assez longtemps pour être dangereux). The kamsin, or south wind, does not occur at Cairo until after the middle of February; . . . occasionally, however, it appears earlier," etc. The following quotation respecting the winds of Egypt is taken from the article on "Egypt" in the "Encyclopædia Britannica."

"The wind most frequently blows from the N.W., N., or N.E., but particularly from the first direction. The proportionate prevalence of these winds to those from all the other quarters, in the year, is about 8 to 3; but to those from the S., S.E., snd S.W., about 6 to 1. (Clot-bey, "Aperçu Général sur l'Egypte," i., p. 30.) The northerly winds are the famous Etesian winds of Herodotus (ii., 20), which enable boats constantly to ascend the Nile against its strong and rapid current, whereas in descending the river they depend on the force of the stream, the main-yard being lowered. These winds also cool the temperature during the summer months. The southerly winds are often very violent, and in the spring and summer, especially in April and May, hot sand-winds sometimes blow from the south, greatly raising the temperature and causing especial suffering to Europeans." Several other special winds are also mentioned in this article in the "Encyclopædia Britannica," but none of them requires mention in this place.

"Finally, it should be remarked that a morning fog is a not infrequent occurrence along the banks of the Nile; but such a fog never lasts more than a few hours, being quickly dissipated by the heat of the Egyptian sun. "On account of the rapidly increasing heat of the spring season, and the especial frequency of occurrence of the kamsin at that season, it is not desirable that invalids should linger in Egypt later than the month of March, and preferably not later than the middle of this month; owing also to the great heat during the early autumn, and to the prevalence of malarial fevers at that season, it is not well for the invalid to go to Egypt before the middle of November, and for such as intend to make the Nile journey, the middle of December is abundantly early to start. Consequently we see that the season for invalids in Egypt is a comparatively short one. . . . . For residence all the year round Egypt is not at all well suited, the summer and autumn heat being far too oppressive. As a sample of the degree of heat which may be experienced in the autumn, it may be of interest to remark that a temperature of 103.5° F. was observed at Alexandria on October 11, 1877, being the maximum temperature for that whole year, and that the month of October is generally warmer than May at that place, while September is nearly as warm as June (Hann, *op cit.*, pp. 422, 423)." (Huntington Richards.)

During the season in Egypt (October to April) we

see from the climatic table that there is no great variation of temperature from day to day, or indeed from month to month, during the five months from November to March. The daily range, however, is great, and there is a very marked contrast between the day and the night temperature, caused by the rapid radiation of heat after sundown from the sands of the surrounding desert.

"Unlike the more irregular falls of temperature, which occur with greater frequency and are apt to be of greater severity in European countries and in a large part of the United States (the land of 'blizzards' and 'cold waves'), these nightly falls of temperature in Egypt may in great measure be guarded against by the invalid, especially if he have taken up his residence at Cairo. Greater precautions are of course necessary to the invalid who is making the Nile journey on board of a dahabeeah, or who has determined to pass the winter living, like the Arabs, in a tent upon the desert. Flannel underclothing should be worn by all visitors to Egypt, and a supply of warm outer clothing and of wraps is necessary as well, especially for those intending to make the river trip, or to convert themselves temporarily, for the benefit of their health, into amateur Bedouins. Not only is it the decided fall of temperature after sunset against which the invalid must be on his guard, but in addition to this (and depending partly upon it and partly upon the moderate humidity of the Nile valley), the precipitation of dew is very abundant, at least in all portions of Egypt lying in close proximity to the river and its bordering tract of arable land." (Huntington Richards.)

The drawbacks of a winter in Egypt, as indicated by Dr. Bentley of Cairo (*British Medical Journal*, December 8, 1894, p. 1300), are (1) that invalids do not consult a physician until they are attacked with a serious illness. (This drawback unfortunately is not confined to the Egyptian climate.) (2) Ignorance of most invalids as to the nature of the climate to which they resort and apparently the want of appreciation of the real object for which they go abroad. (It is a question if this ignorance is not rather to be ascribed to the home physician.) (3) Opportunities which exist of sightseeing and social gatherings with their attendant evils—overfatigue, overcrowded rooms, and late hours. (4) Occasional cold high winds, and at times unreliable weather. (5) Sudden and sometimes marked fluctuation of temperature between day and night, sunshine and shade. (6) Hot winds (kamsin) which commence in February, blow for about two days at a time, and are accompanied by fine particles of sand suspended in the air.

As has been said, Cairo should not be selected by the invalid for a lengthy sojourn. If, however, one is simply desirous of rest and diversion, and is otherwise well, he will find innumerable ways of amusing and forgetting himself in this great Oriental city. For the true invalid, however, and especially for the tuberculous patient, the noise, dust, and attractions of Cairo are to be avoided by selecting either Gizeh, Helouan, Luxor, or Assouan, or by taking a voyage up the Nile, or by camping in the desert.

At *Gizeh*, eight miles from Cairo, is the English hotel, Mena House, on the edge of the desert, affording first-class accommodations, with a resident physician and chaplain, a swimming bath, and arrangements for tennis, croquet, and golf. "The invalid spends his time in the desert, enjoying its invigorating air from morning till night. He may find rest, almost complete immunity from rain, and unlimited sunshine. It is an invaluable health resort for those who wish to avoid the fatigue and expense of the journey up the Nile" (E. Symes Thompson). In December and January the winds are said to be often cold here, and the changes of temperature sudden and great, so that one must be provided with warm outer garments. After sunset, the cold, by comparison, seems severe, and one must be careful to avoid a chill. The temperature is practically that of Cairo, and the humidity lower.

*Helouan* is fourteen miles by rail from Cairo, situated in the desert, and contains two large and comfortable hotels, numerous *pensions*, and houses for rent. It is said to have a remarkably dry and sterile atmosphere, and has become not only a favorite locality for invalids but a residential suburb of Cairo. There are hot sulphurous springs at Helouan which "have long enjoyed a reputation for chronic rheumatic affections." The baths are well constructed and resemble those at Aix-les-Bains.

*Luxor*, 450 miles from Cairo, at the first cataract of the Nile, is reached by rail from the latter city, or one can take the slower method of river navigation. It is dryer, warmer, and sunnier than any of the resorts about Cairo; "several winter seasons often pass without a shower" (Thompson). The following table from Sandwith gives the climatic details:

Climate of Luxor for the Winter Months.

| Data. | November. | December. | January. | February. | March. |
|---|---|---|---|---|---|
| Temperature (deg. Fahr.)— | | | | | |
| Average or normal | | | 56.7° | 62.6° | 66.9° |
| Average daily range | | | 23.7 | 31.7 | 38.4 |
| Mean of warmest | 78.9° | 70.6° | 65.1 | 70.6 | 80.1 |
| Mean of coldest | 62.1 | 53.6 | 41.3 | 42.4 | 47.6 |
| Highest or maximum | 94.0 | 77.0 | 83.0 | 86.0 | 110.0 |
| Humidity— | | | | | |
| Average relative | | | 53.2% | 51.0% | 45.0% |
| Precipitation— | | | (Not known.) | | |
| In inches | Minute | fraction | of an | inch, if | any. |
| Wind— | | | | | N. W. |
| Prevailing direction | S. W. | N. E. | N. W. | N. W. | N. E. |
| Average hourly velocity | 0.1 | 1.8 | 1.0 | 1.1 | 0.7 |
| Weather— | | | | | |
| Clouds (0–10) | | | 2.9 | 1.9 | 2.1 |

"The sky was noted as being completely overcast four times in January, once in February, and three times in March."

December, January, and February are considered the most available months for Luxor. The town has 4,000 inhabitants, with two good hotels and English physicians. "The invalid should not leave the house before 10 A.M. or remain out after sunset." During these three months the bedroom temperature is generally above 63° F. As seen from the table the daily range of temperature is great. The drinking-water, as is generally the custom, comes from the Nile and is filtered. There is much of interest in and about Luxor in the many Egyptian ruins and antiquities.

Assouan is 133 miles higher up the river than Luxor, 583 miles south of Cairo. Besides being warmer than Luxor, its climate is about the same, although the air is said to be freer of dust storms. There is a large and comfortable hotel here, and as rain never falls, the roofs are carpeted, with easy chairs in the shady corners. The air is so dry that the heat is not uncomfortable, and the same clothing is recommended to be worn as in an English winter. Here, as elsewhere, the cool night air is to be avoided.

The Nile voyage is best made between November and March, and one can make the journey either by steamer or dahabiyeh; the latter method is of course the most enjoyable, and weeks may be occupied in making it. The steamers have at least one advantage, that of carrying a physician. "If there is anything in life," says Peterson, "which will steal away worries and cares, soothe the tired brain, calm the unstrung nerves, bring back vagrant sleep, it is the dream-like voyage on the Nile in a dahabiyeh." For an invalid, however, particularly if he is suffering from throat or lung trouble, this delightful journey is not without

its risks; for the nights are cold and frosty, the mists cover the river in the early mornings, and the wind is sometimes strong and "dangerously cold for an invalid."

Camping in the desert, when this method of life is available, is perhaps the most effectual means of utilizing the advantages of the Egyptian climate. "Our experience of treatment," say Weber and Foster in Allbutt and Rolleston's "System of Medicine," vol. i., 1905, "by continued residence during several entire years in the Nubian desert under tents shifted from one place to another, has, in several advanced cases of consumption, given results which are altogether superior to any obtained from any health resort or from any other treatment." "Camp life in Egypt," says Peterson, "is something luxurious. Labor and carrying cost next to nothing, and everything in the way of furniture and supplies can be stored away somewhere on a canal. Every day can be foreseen to be rainless and beautiful; life in tents becomes a pleasure."

The diseases for which the Egyptian climate is to be recommended are: (1) Pulmonary tuberculosis in the early or advanced cases, if the conditions are not acute; hemorrhagic cases; cases associated with bronchitis. Benefit is said also to be obtained in the first, second, or third stage of the disease, if not acute, especially when the origin of the affection was pneumonic, bronchopneumonic, or pleuritic. Both C. T. Williams and Sandwith give series of cases with fairly favorable results. (2) Chronic bronchitis and emphysema; asthma. (3) Rheumatism and rheumatic arthritis. (4) Bright's disease and albuminuria. (5) Chronic nasal and pharyngeal catarrh and deafness dependent upon abnormal conditions of the Eustachain tube. (6) Convalescence from pneumonia, pleuropneumonia, and pleurisy, and various acute specific diseases. (7) Neurasthenia and cases of mental strain and breakdown. (8) Atheroma and arteriosclerosis. (9) Hemiplegia and paresis. (10) Anemia. (11) Heart disease. (12) The old and prematurely aged. (13) Neuralgias.

The cases for which this climate is contraindicated are: (1) Intestinal ulceration, chronic dysentery, or any tendency to diarrhea. (2) Well-marked diabetes. (3) Laryngeal ulcerations. (4) Rapidly advancing and active phthisis. (5) Tuberculous kidneys.

"The advantage of the Egyptian climate in the treatment of pulmonary tuberculosis lies in the warm sunny days, the dryness of the atmosphere, and the aseptic character of the air. Its drawbacks are: the short time of year during which it is available, and the danger of contracting chills, chiefly abdominal" (Weber and Foster, Allbutt and Rolleston's "System"). The hygienic-dietetic treatment of phthisis in a well-conducted sanatorium, in almost any temperate climate, where pure air, sunshine, and freedom from dust and wind can be obtained, would probably give a much higher average of favorable results; for the treatment could be continued uutil the cure had been effected, without change of locality, and, what is of vital importance, the patient would be under constant medical supervision, and would be kept up to the strenuous work of getting well.

The expense of living and travelling in Egypt is greater than in most European countries, but probably no greater than in the United States for the same accommodations, if as great. One can now take a steamer from New York and go directly to Alexandria, or go from London, Plymouth, Marseilles, Naples, Genoa, or Venice. The steamers from New York to Genoa, Naples, or Alexandria are large and comfortable, and going by the "southern route" the voyage is likely to be a smooth one.

For further consideration of the climate of Egypt, one is referred to "Egypt as a Winter Resort," by F. M. Sandwith of Cairo, 1889.—"The Climate of Egypt," by E. Symes Thompson, M.D. *The Practitioner*, 1895, vol. lv., p. 532.—"Notes on Egypt as a Health Resort," by P. Watson Williams, M.D. *Bristol Medico-Chirurgical Journal*, 1895, vol. xiii., p. 262.—"Wintering in Egypt," by Frederick Peterson, M.D. *Medical Record*, 1892, vol. xlii., p. 205. Huggard, "A Handbook of Climatic Treatment," 1906.

EDWARD O. OTIS.

**Eimeria.**—A genus of *Coccidia*, in the *Polysporocystidæ*, where the oöcyst has many spores. The cysts of *E. hominis* have been found in human feces, and in rabbits' intestines; *E. stiedæ* is found in the liver of rabbits. See *Protozoa*. A. S. P.

**Elaps.**—A genus including the coral snakes, which are conspicuously banded with rings of black and yellow. The poison fang is grooved, not hollow, and the bite of these snakes is usually not very serious.

A. S. P.

**Elastica.**—RUBBER. *Caoutchouc*, Fr. Cod.; *India rubber, Gum elastic*, etc. The concrete milk juice of several species of *Hevea*, Aubl. (fam. *Euphorbiaceæ*), known in commerce as *Para rubber*.

From a commercial standpoint, the substance bearing the above names is derived from a large number of milky-juiced plants, growing in the tropics of both the Old and the New World, these plants belonging to many and distantly related families, but more especially, in the order named, to the *Euphorbiaceæ*, *Urticaceæ*, *Apocynaceæ*, and *Asclepiadaceæ*. Besides these, which yield rubber on a commercial scale, the substance caoutchouc occurs in small amounts in a very large number of milk juices.

The rubbers from these different botanical sources naturally differ widely in appearance and quality. Some of them—perhaps more because of the manner in which the milk juices are treated than because of natural differences in the latter, they being often mixed with ashes, soap, and other substances, and allowed to ferment in holes in the ground—are quite unfit for official use. Others, though clean, and not, strictly speaking, objectionable, are inferior from the standpoint of deficiency in their useful properties. Para rubber has been selected for official purposes because of its cleanliness, purity as caoutchouc, high elasticity, durability, and ready solubility in appropriate liquids.

ORIGIN.—The plants yielding Para rubber are large trees, frequently exceeding a hundred feet in height and five or six feet in diameter, growing in the valleys of the Amazon and its tributaries. The basin of the Madeira and its tributaries produces the largest amount. Though mostly exported viâ Para, whence the name, much of the same grade comes out through the west coast of South America. The milk juice is obtained by gently tapping the outer and middle bark layers with a sharp pick and catching the exudation in small cups attached to the trees. The milk is then gathered and carried to the smoking stations, where it is coagulated in successive layers upon a flat wooden paddle, by being held in the smoke of smothered fires, special articles being preferred for this fuel. When a suitable quantity has been gathered upon the paddle, an incision is made at the upper end of the mass, called a *bolacho* or "bottle," to permit of its being slipped off from the end of the paddle. It then possesses a flat form, a whitish color, and smooth surface, and may weigh from a few up to seventy-five pounds, or even more. The product of the upper tributaries is usually in bolachos of about twenty-five pounds, the larger bolachos coming mostly from the lower Madeira. The rubber soon begins to turn yellow, then brown, and ultimately black, first upon

the surface and then gradually toward the interior, the complete process of darkening requiring several years. At the same time it loses water, and of course weight. It may be exported in the original bolachos, but owing to the danger of adulterants in the form of sand, stones, etc., it is now mostly cut into small pieces in Para.

Description.—The following is the official description of elastica: In cakes, balls, or hollow, bottle-shaped pieces, externally brown to brownish-black, internally brownish or of lighter tint; very elastic; insoluble in water, diluted acids, or diluted solutions of alkalies; soluble in chloroform, carbon disulphide, oil of turpentine, benzin, and benzol. When heated to about 125° C. (257° F.) it melts, remaining soft and adhesive after cooling. Odor faint, peculiar; nearly tasteless.

Composition.—The percentage of caoutchouc in India rubber varies with the amount of water which the substance has lost. In its original liquid condition there is said to be about thirty-two per cent. of this hydrocarbon ($C_{20}H_{32}$). With caoutchouc exist a little wax, a free acid, and some protein matter. The decomposition of the protein matter would seriously injure the quality of the rubber, and it is to prevent such decomposition that creosote is introduced by the smoking process. There is a little free carbon, which results from the smoking process.

Properties and Uses.—On continued exposure to the atmosphere, rubber undergoes changes which render it brittle and weak, and this may be prevented by keeping it under water, which preserves it by inducing superficial fatty changes. *Vulcanized rubber* is produced by combining the original rubber with sulphur, under the influence of heat, by various processes. It still retains its elasticity, but becomes harder and is no longer soluble in the same liquids as before. *Hard rubber* or *ebonite* may be obtained by combining rubber with various other substances than sulphur.

Strictly speaking, rubber has no medicinal properties, since it is insoluble in all the fluids of the body. The original milk, when drunk by mistake, has invariably coagulated into an insoluble mass in the stomach, the result being fatal in the absence of surgical treatment. Its uses are wholly mechanical. The most important is as a mass for plasters. Such a mass possesses very good qualities, although experiments seem to indicate that the effect of the incorporated medicinal substance is somewhat less than when combined with the official plaster mass. Rubber-mass, adhesive plasters for surgical dressings, Esmarch's and other elastic bandages and wrappings, orthopedic appliances, nipples, syringes (hard and soft), pessaries, artificial teeth, specula, catheters, etc., represent important uses of rubber, which require only enumeration. Articles of rubber, either hard or soft, should be kept in a closed box or drawer, and occasionally used or washed to prevent their becoming too dry and brittle. Silver instruments should never be kept in the same enclosure with them. Soft rubber is spoiled after a short time by oils and fats, and eventually hardens in spite of precautions.

By dissolving rubber in appropriate liquids, with or without the addition of other adhesives, various forms of cement or glue can be obtained, and impervious coverings can be produced by applying such substances and permitting evaporation.

Henry H. Rusby.

**Elastin.**—This is an albuminoid, the characteristic basis of yellow elastic connective tissue. It is found in the cervical ligament most abundantly. Insoluble in nearly all the common reagents elastin is nevertheless dissolved by both gastric and pancreatic secretions, giving rise to substances that correspond to proteoses and peptones. This albuminoid differs from typical proteins in containing no aspartic acid, very little glutamic acid, hexone bases, and sulphur. Frank P. Underhill.

**Elaterinum.**—Elaterin, a neutral principle first obtained by Morries and Hennell in 1831 from elaterium (*q.v.*). It is a definite chemical combination of the formula $C_{20}H_{28}O_5$, and is thus described: Minute, white, hexagonal scales, or prismatic crystals, without odor, and having a slightly acrid, bitter taste; permanent in the air. Soluble, at 15° C. (59° F.), in 4,250 parts of water, and in 337 parts of alcohol; in 1,820 parts of boiling water, and in 34 parts of boiling alcohol; also soluble in 543 parts of ether, or in 2.4 parts of chloroform. At 190° C. (374° F.) the crystals begin to agglutinate, and at about 209° C. (408.2° F.) they melt, forming a yellowish-brown liquid. When ignited, they are consumed without leaving a residue. Elaterin is neutral to litmus paper. Elaterin is dissolved by solutions of the alkalies, and reprecipitated on supersaturating with an acid. When dissolved in cold, concentrated sulphuric acid, it causes the latter to become yellow at first, which color gradually changes to scarlet. On dissolving some crystals of elaterin in melted carbolic acid, and then adding a few drops of strong sulphuric acid, a crimson color will be developed which soon becomes scarlet. An alcoholic solution of elaterin should not be precipitated by tannic acid T.S., mercuric chloride T.S., or platinic chloride T.S. (absence of, and difference from, alkaloids). (U. S. P.)

Action and Use.—Elaterin is the most active and certain of known hydragogue cathartics, purging repeatedly and comparatively painlessly in exceedingly minute doses. In larger ones, colic, nausea, vomiting, and prostration may follow. It is especially indicated when there is no inflammatory trouble in the digestive tract, and it is desirable both to empty the latter of its contents and to secure a copious transudation of water from the blood to its canal. Such conditions are frequently present in cardiac and renal diseases, accompanied by general dropsy; occasionally also in ascites from various causes, and in cerebral congestion, plethora, concussion, or compression of the brain, etc. For all these there is no better hydragogue than this. To be efficient, it should be given by the mouth, as it is very much less active in injections either into the rectum or into the cellular tissue; and in inunction it scarcely produces any but local effects. It is said, further, that the presence of bile in the intestines is essential to its full effect; but the proposition can scarcely be considered as finally settled. It is, no doubt, necessary that the intestinal contents should be alkaline.

Upon dogs, rabbits, and some other animals, it is an uncertain cathartic, and may even kill by nervous depression, without moving the bowels at all. After death by it, in man, signs of gastrointestinal inflammation have been present.

Dose.—Elaterin is best given in pill form in doses of gr. $\frac{1}{40}$–$\frac{1}{10}$ (0.0015–0.006). The official trituration (*Trituratio elaterini*, U. S. P.), strength $\frac{1}{10}$, is a convenient form for administration in doses of gr. $\frac{1}{4}$–j (0.015–0.06). W. P. Bolles.

**Elaterium.**—This drug, official in the British Pharmacopœia, but no longer so in that of the United States, is the dried sediment from the juice of the fruit of the wild or squirting cucumber, *Echallium elaterium* (L.) A. Richard (fam. *Cucurbitaceæ*), a small perennial or, in temperate climates, sometimes annual herb, with a fleshy, tapering root, and succulent, prostrate,

cucumber-like stems. The fruit, which is also official in some countries, where the plant grows, is from three to six centimeters long, by one or two in diameter (one to two and one-fourth inches by one-third to two-thirds inch), oblong, ovoid, covered with fleshy, tapering; soft bristles, and of a yellowish-green color. Texture firm externally, but soft and very watery in the middle. At maturity the tension produced by the accumulation of liquid within the pericarp becomes so great as to burst the fruit at the base, forcing off the peduncle, with a squirt of the soft contents, seeds and all, to a considerable distance. From this peculiar mode of distributing its seeds the plant has received its name (ἐκβάλλω), I throw out. The seeds are numerous, compressed, ovoid, smooth, brown; they also were formerly employed.

This plant is indigenous to Persia, India, and the warmer Mediterranean countries. It has also been naturalized and cultivated in various parts of Europe. It is raised in England and elsewhere for medicinal use. It is a very old medicine, having been mentioned before the Christian era.

The fruit, for medicinal purposes, should be gathered just before it is wholly ripe, and, of course, before it has expelled its contents. There are several ways of collecting elaterium, two of the best being as follows: The British Pharmacopœia formerly directed to "Take of the squirting cucumber fruit, very nearly ripe, one pound. Cut the fruit lengthwise, and lightly press out the juice. Strain it through a hair sieve, and set it aside to deposit. Carefully pour off the supernatant liquid; pour the sediment on a linen filter, and dry it on porous tiles in a warm place. The decanted fluid may deposit a second portion of sediment, which can be dried in the same way." Clutterbuck saved the juice of the sliced fruit, and then scooped the soft pulp out with the thumb, threw it upon a sieve to drain, and washed it with water without pressure. These liquids were set aside, and the precipitate collected and dried as above. This method produced a very fine quality of elaterium, which has been famous for more than half a century. Elaterium appears to be good in proportion to the near approach to ripeness of the fruit used, and to the absence of pressure in manipulating it. The continental grades of this article are generally inferior to the English.

The poorer, German elaterium, comes in thicker (about one-fourth inch) cakes, largely wanting in the greenish color and sparkling appearance of the English. It is about one-fourth as strong. The yield of the fruit is about 0.123 per cent. of elaterium. Besides the active principle, coloring matter, cellular tissue, starch, ash, and water make up the rest.

Administration.—Elaterium is very variable in its strength, and while of Clutterbuck's or the best English the dose is about a centigram (gr. $\frac{1}{6}$ to $\frac{1}{8}$), that of the ordinary Malta or German varieties may be five or six times as large. In an untried sample, the smaller dose should always be started with and increased until found to be sufficient. For a discussion of the action and uses of elaterium, see the article *Elaterinum*. This drug, which is a neutral principle obtained from elaterium, and of definite strength, should always be administered in preference to the latter. W. P. Bolles.

**Elbow.**—*Extent.*—The term elbow is often used to indicate merely the angular projection made between the arm and forearm. The region of the elbow includes the joint and all the parts that surround and cover it. Externally there are no well-marked lines that separate this region from the arm above or the forearm below, and the rule established by Tillaux of limiting its boundaries to two finger-breadths above and two below the transverse cutaneous fold caused by the flexion of the joint, is probably as good as can be devised.

*Configuration.*—(See Fig. 1944.) In shape this region differs from those above and below, being somewhat broader, flatter, and hollowed on the volar surface by a shallow depression known as the cubital fossa, distantly resembling the popliteal space behind the knee, while dorsally a rounded projection appears even in the most extended state of the arm. These peculiarities of shape are due partly to skeletal form and partly to muscular grouping. On either side project the epicondyles of the humerus with muscular masses arising therefrom; dorsally, the olecranon of the ulna forms the "point of the elbow" already mentioned. In front and behind, the muscles that have formed the rounded bulk of the upper arm become reduced to tendinous bands, thus occasioning the anteroposterior flattening.

The cubital fossa is shaped somewhat like a swallow's tail, hence the older anatomists called it the chelidon (χελιδών, a swallow). This shape is determined by the two converging muscular masses arising from the condyles on either side, between which is wedged the rapidly decreasing mass of the muscles descending from the front of the upper arm.

The bony landmarks about the elbow are of extreme importance in the diagnosis of injuries and as guides in surgical operations. Laterally the lateral supracondylar ridge may be felt and readily traced downward to the lateral epicondyle. Below and dorsally to this, between eminences caused by the brachioradialis together with the radial extensors of the wrist on the outer side, and the anconæus medially, there is a depression, well marked in all individuals, at the bottom of which there may be felt the head of the radius.

At the medial side the medial epicondylar ridge may also be traced by pressing deeply. Occasionally there is found here, at a distance of one or two inches above the medial epicondyle, a bony hook known as the supracondyloid process. From the summit of this hook there extends to the epicondyle a fibrous band affording origin to part of the humeral head of the pronator teres muscle, and through the osteofibrous canal thus formed pass the brachial artery, or one of its branches, and the median nerve; the presence of this process is said to be associated with a high division of the brachial. This arrangement occurs in about one per cent. of individuals and appears to be the homologue of an osseous canal found in many mammals, such as carnivores, rodents, and some inferior apes.

The medial epicondyle is sharper, a little higher, and not so well covered with muscles as the lateral one. It is therefore more prominent and must be carefully padded when splints are applied at the elbow. Its most prominent part is directed backward rather than inward. Between it and the olecranon is the groove by which the ulnar nerve passes to the lower arm.

The olecranon projects more or less in all positions of the joint. Its proximal border is obscured by the tendinous insertion of the triceps, which usually has a bursa beneath it. A subcutaneous bursa is almost invariably found over that portion of its surface on which the weight rests when leaning on the elbow. The relative position of the proximal border of the olecranon and the two epicondyles varies according to the degree of flexion of the joint. When it is fully extended, the three prominences are in line; when at a right angle, the border of the olecranon is immediately beneath the epicondyles; in extreme flexion it is in front of them. These relations are important in judging of a dislocation, but unfortunately most cases are not seen until the swelling is so great that it is impossible to apply them accurately.

When the arm is strongly pronated, the tuberosity of the radius may usually be felt below the joint, in the interval between the radius and the ulna. The shaft of the ulna is much more easily felt than that of the radius.

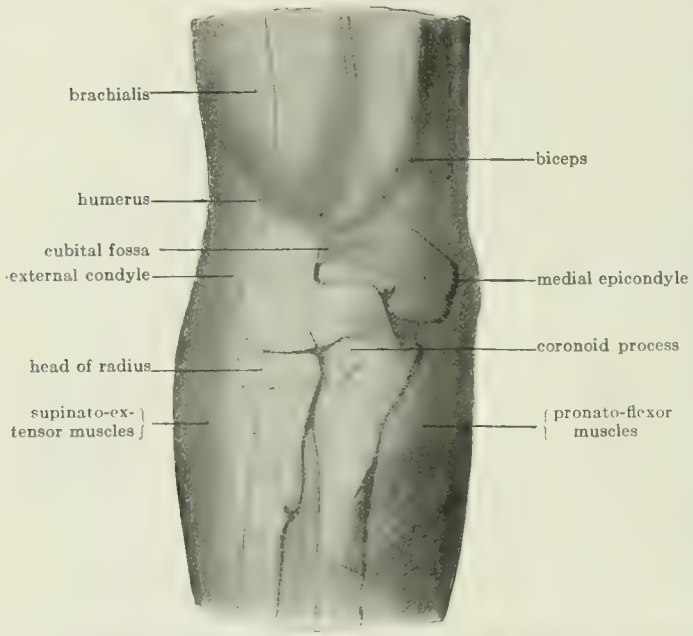



Fig. 1944.—Volar Surface of the Elbow, the Bones showing as if the Parts were Semitransparent.

The front of the joint is so well covered by muscles that but little aid can be obtained from bony landmarks. However, deep pressure at the bottom of the cubital fossa will, in lean individuals, reveal the tip of the coronoid process of the ulna.

*Skin.*—The skin in front of the elbow is especially thin, delicate, and transparent, the course of the subcutaneous veins being, in the white races, clearly visible through it. It is also readily movable. Because of these peculiarities care must be taken to avoid any considerable traction upon it when apparatus is used in this region, as it is easily excoriated and ruptured.

During flexion there appears in front a transient fold of skin which disappears on complete extension, differing in that respect from the folds of the fingers and palm. It is better seen in young children than in adults. It lies some distance above the line of articulation and should not be used as a surgical guide. According to Soulié it is usually 17.5 millimeters above the line of the joint and forty-two millimeters above the division of the brachial artery into radial and ulnar. The articular line runs somewhat obliquely medially and downward, being about two centimeters below the lateral epicondyle and three centimeters below the medial epicondyle.

*Superficial Fascia, Vessels, and Nerves* (see Fig. 1945).—The subcutaneous fat or superficial fascia varies very much in different individuals. It may be sufficient to conceal the subcutaneous veins and be separable into two sheets between which the veins run. Embedded in it, just above the medial epicondyle, are a few lymphatic glands which receive the converging, superficial lymphatic trunks arising from a network about the lower arm and hand. These glands should be examined in case of suspected malignant growth in those regions.

The superficial veins at the elbow were formerly much used for the operation of blood-letting or venesection, and are still occasionally opened for that purpose. The reason for this choice is obvious. They are easily accessible and situated upon a portion of the body frequently exposed to view. They are also of sufficient size to make the operation effective, which is not usually the case with trunks more distally situated, and, with reasonable care, no untoward results need ensue. The anatomical relations should, however, be carefully studied. Their general course can be effectively shown in the living subject by binding a ligature just above the elbow sufficiently tight to retard the flow of blood in the superficial veins without arresting the current in the brachial artery.

According to the classical description, the superficial veins at the elbow consist of collateral anastomoses between two principal trunks which, running lengthwise up the forearm, are respectively known as the cephalic and the basilic

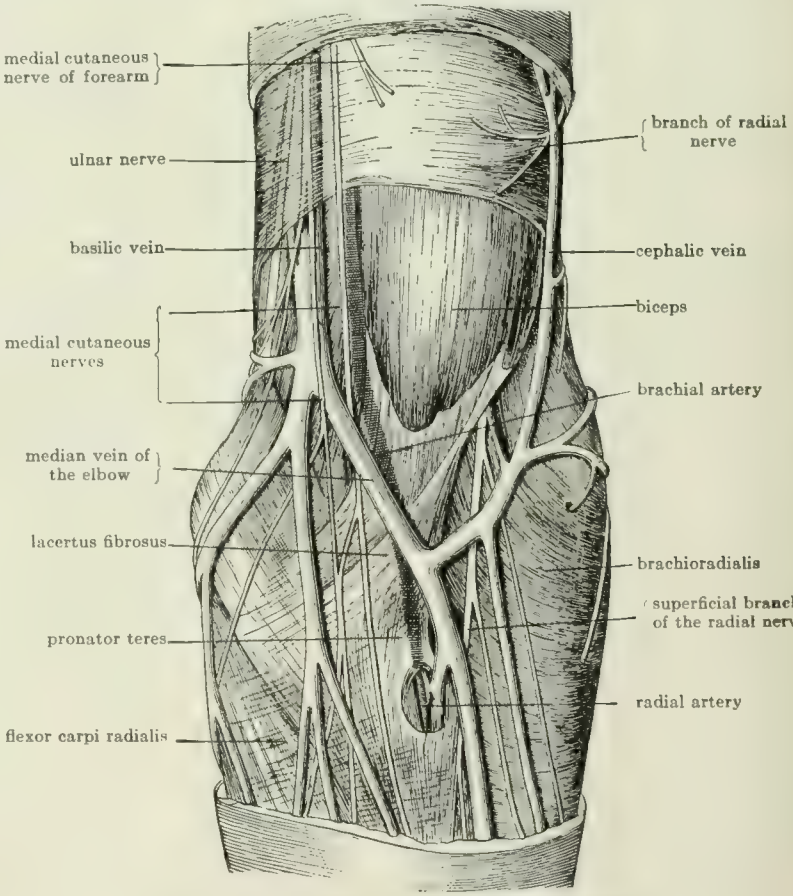



Fig. 1945.—Superficial Dissection of Region of Elbow.

veins. Above the elbow the cephalic runs up in the lateral bicipital groove as far as the shoulder, and the basilic follows the medial bicipital groove about one-third the way up the arm when it pierces the deep fascia, leaving an opening known as the hiatus semilunaris. At the bend of the elbow the cephalic is connected with the basilic by an oblique anastomosing vein, the median vein of the elbow. There is also frequently found a vein, the accessory cephalic, that winds around the radial side of the forearm and unites near the lateral epicondyle with the cephalic. Quite frequently also there is a vein, the median vein of the forearm, that commences in the palmar venous plexus and runs up the middle of the forearm, bifurcating at the bend of the elbow, giving one branch, the median cephalic, to the cephalic vein, another, the median basilic, to the basilic. When this is present the median vein of the elbow is absent. An anastomosing trunk, the profunda vein, pierces the deep fascia at the elbow and connects this system with the deep veins of the forearm.

This arrangement is usually compared to a capital M, yet that imperfectly describes it, as the uprights must be extended both upward and downward and an additional member be added at the union of the diverging bars (see Fig. 1945).

The pattern thus sketched out is, however, by no means constantly followed (see Fig. 1946). The median vein is often replaced by a plexus; there may be

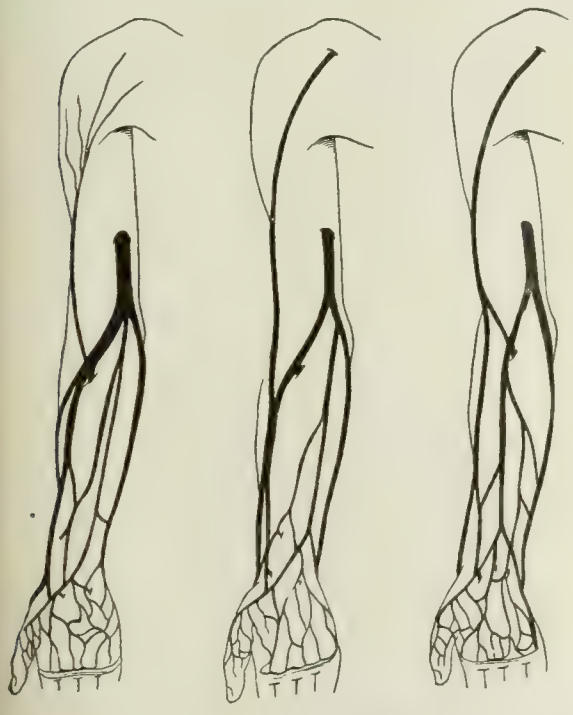


Fig. 1946.—Variation in the Veins of the Arm.

two or more veins replacing the cephalic or basilic that unite either above or below the elbow; frequently the cephalic vein forms the so-called median cephalic and median basilic, while the accessory cephalic constitutes the outer vertical bar of the M. In this case, the median vein, if there is one, discharges either into the cephalic before it divides or into the basilic.

The median basilic or median vein of the elbow, usually larger, more superficial, and more constant than the median cephalic, runs almost parallel with the brachial artery just before its division, being separated from it by the fibrous expansion from the tendon of the biceps to the deep fascia of the lower arm (lacertus fibrosus). This gives it a somewhat firmer support when the arm is fully extended than can be afforded to the median cephalic, which is surrounded by yielding subcutaneous fat.

The vessels differ also in their relations to the cutaneous nerves that cross the cubital fossa to supply the lower arm. The medial cutaneous nerve of the forearm breaks up, at some distance above the elbow, into several branches, the largest of which, piercing the deep fascia at the hiatus semilunaris, usually passes down in front of the basilic and median vein of the elbow, sometimes forming a rich plexus along the latter vessel. On the radial side the cutaneous branches of the musculo-cutaneous nerve emerge from the deep fascia a little above or on a level with the lateral epicondyle. This is the most effective spot for its electrical excitation. It lies directly inward from the confluence of the median cephalic with the cephalic. Running along the median cephalic for a short distance, it divides into volar and dorsal branches, which supply corresponding surfaces of the forearm. Both of these usually descend behind the vessel, though occasionally the volar branch passes in front.

The larger size and firmer bed of the median vein of the elbow make it easier to open, but its close proximity to the artery occasions accidents and the number of nervous filaments that must be cut to reach it is disadvantageous, as their section sometimes leads to painful neuritis. Notwithstanding these disadvantages the median vein of the elbow (median basilic) is usually selected for venesection because of its larger size and greater fixity of position.

*Deep Fascia.*—(Fig. 1945.) This is continuous above with the deep fascia of the arm, below with that of the forearm. The intermuscular septa, so marked a feature of the fascia of the arm, are continued downward into the region of the elbow. The medial septum is the stronger, and lies between the brachialis and the medial head of the triceps, attached to the supracondylar ridge as far as the medial epicondyle. The lateral intermuscular septum is mainly represented in this region by the muscles attached to the lateral supracondylar ridge, viz., the brachioradialis and the extensor carpi radialis longus, which lie between the brachialis and the lateral head of the triceps.

At the elbow-joint the fascia becomes closely adherent to the muscles, to the epicondyles, and to the olecranon. It here receives several reinforcements, viz., from the tendon of the biceps, the fibers passing over toward the medial epicondyle and the crest of the ulna; from the triceps by expansions on either side of its tendon of insertion; an anterior fascicle from the medial epicondyle; a posterior fascicle from the lateral epicondyle; and fibers from the dorsal margin or crest of the ulna. From either condyle it sends down strong intermuscular septa between the muscles that arise therefrom, thus affording them additional areas of insertion. Except where reinforced it is thin but somewhat thicker on the extensor surface of the arm. The general direction of the fibers of this fascia is circular, girdling the arm, but the fascicles of reinforcement are either longitudinal or oblique. At the point of the cubital fossa it is perforated by the profunda vein.

*Muscles.*—The muscles about the elbow are arranged somewhat like the links of a chain, the flexors and extensors of the lower arm lying on the volar and dorsal surfaces of the limb, while the pronators and supinators are at the sides. The mass coming down from the upper arm in front is composed of the biceps and the brachialis (see Figs. 1947 and 1948).

At the elbow the biceps develops from its fleshy portion a strong flat tendon that lies at first in the frontal plane, but as it descends into the cubital fossa, twists so that its lateral border becomes anterior. Passing deeply between the radius and ulna it is inserted upon the dorsal portion of the bicipital tuber-

osity. A bursa (*B. bicipitoradialis*) constantly intervenes between the volar portion of the tuberosity and the tendon, and not infrequently a second bursa (*B. cubitalis interossea*) is found between its medial surface and the ulna, lying along the oblique cord. It is because of the insertion of the tendon near to the dorsal surface of the radius that the biceps is enabled powerfully to rotate that bone and thus supinate the hand. Owing to its preponderating influence, the force available for supination is much greater than that for pronation. This is turned to account in many tools and mechanical devices, such as gimlets and screws.

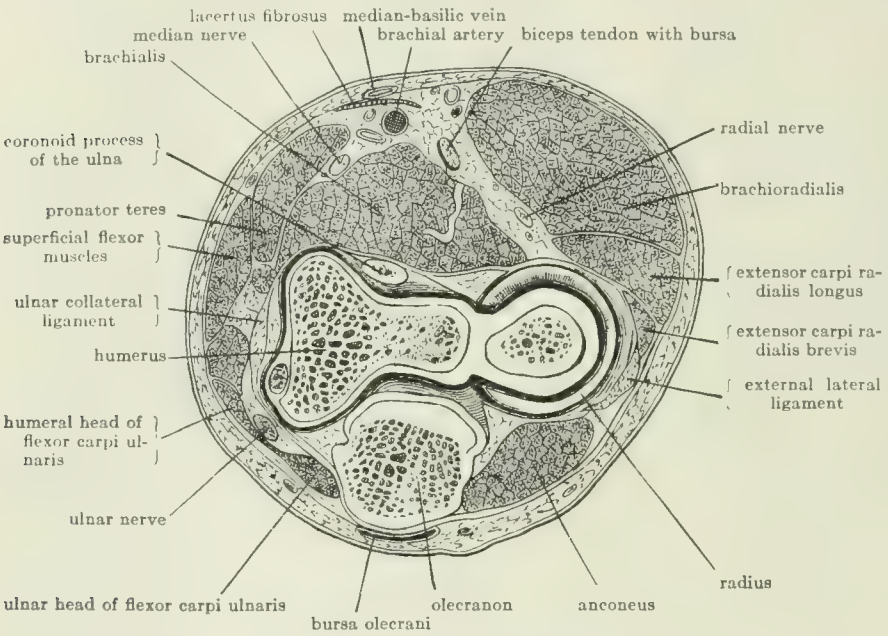



Fig. 1947.—Horizontal Section through Elbow.

Arising from the volar surface and medial border of the main tendon of the biceps is the aponeurotic expansion known as the *lacertus fibrosus*, which is directed obliquely to the medial side of the forearm, its fibers reaching as far as the crest of the ulna. It has therefore been regarded as an ulnar tendon of the biceps. It passes over the brachial artery and the median nerve, separating them from the median cubital vein and the filaments of the medial cutaneous nerve of the forearm.

The *brachialis* lies beneath the biceps, directly in front of the elbow-joint. Thick and flat, it arises by direct implantation of muscular fibers from the distal portion of the humerus and the intermuscular septa, and is inserted by a broad, flat tendon upon the tubercle and the distal surface of the coronoid process of the ulna. Being broader than the biceps, it becomes subcutaneous at the sides of the arm.

*Vessels.*—In close relation with these muscles there pass down into the cubital fossa the *brachial artery* with its accompanying veins and the median and radial nerves (see Figs. 1945, 1947, and 1949). The artery lies upon the brachialis against the medial side of the biceps muscle, almost exactly midway between the epicondyles. In this situation the position of the artery is clearly indicated by the broad, glistening white tendon of the biceps on its lateral side and the smaller, rounder, and more yellowish cord of the median nerve that runs parallel to its medial border. It usually divides into its terminal branches, the radial and ulnar arteries, just distal to where the lacertus fibrosus stretches over it, viz., about a finger's breadth distal from the bend of the elbow, opposite the junction between the head and the neck of the radius. It is associated with two companion veins that intercommunicate by numerous transverse branches, increasing somewhat the difficulty of isolating the artery for ligation. Its depth and confined position make it possible to compress it by strongly forced flexion of the joint, and hemorrhage from the radial or ulnar arteries may be thus controlled. The lacertus fibrosus acts as a reinforcement of its outer coat, and this is thought to be one reason why aneurysm is much less frequent here than in the popliteal space of the lower limb. It should be noted that the thickness of the lacertus fibrosus varies much in different individuals, being not infrequently so thin and indistinct that it might be mistaken for ordinary connective tissue.

Collateral branches from the large vessels mentioned above form about the elbow a network (*rete articulare cubiti*) of arterioles important for the nourishment of the region (see Fig. 1950). For this reason tight bandaging is likely to interfere with healing processes in the neighborhood of the elbow. The branches that form this network are, from above, the profunda

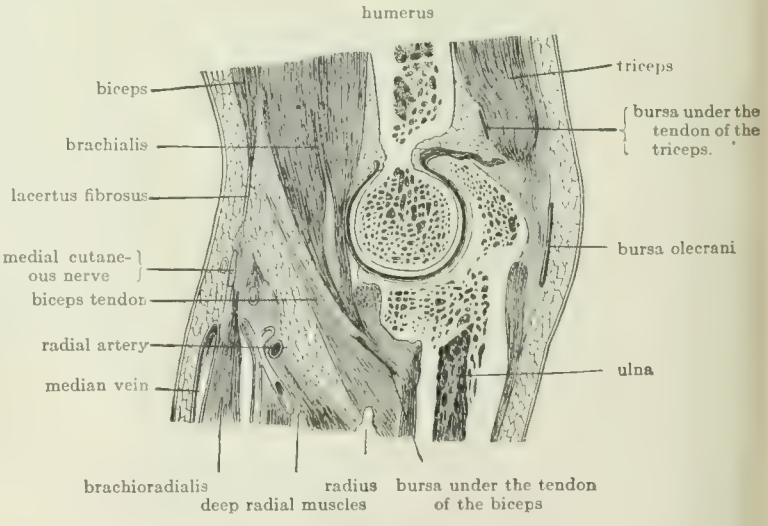



Fig. 1948.—Sagittal Section through Elbow.

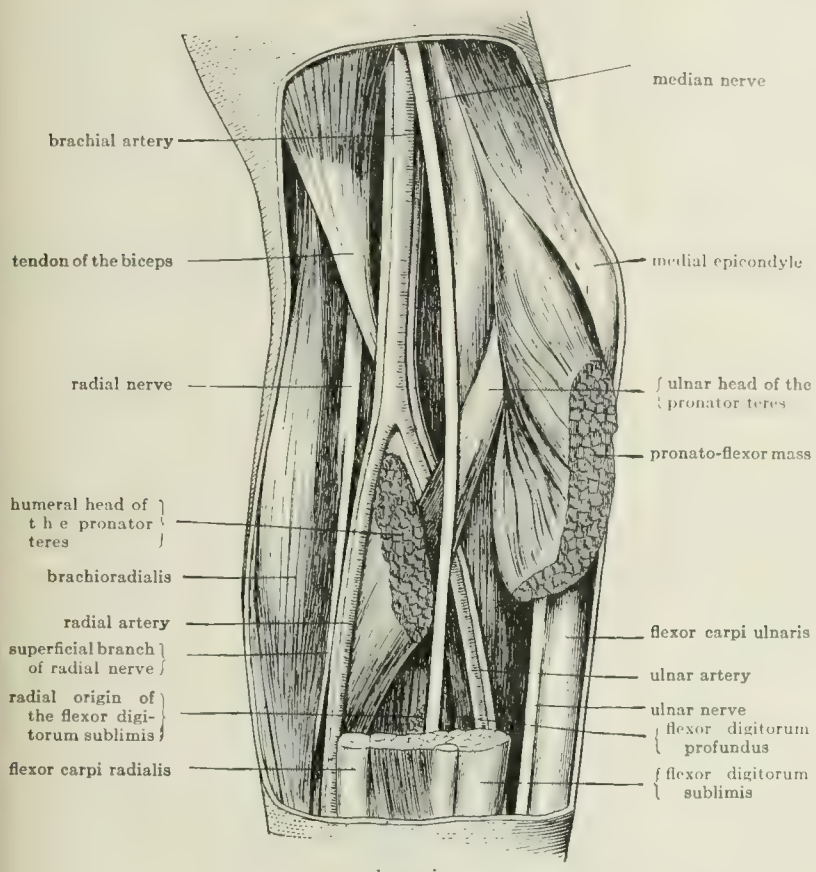



Fig. 1949.—Deep Dissection of the Elbow

artery of the arm and the superior and inferior ulnar collateral arteries, derived from the brachial; from below, the radial recurrent, the interosseous recurrent, and the volar and dorsal ulnar recurrents. About the lateral epicondyle branches from the profunda artery descend, anastomosing with the radial recurrent in front and the interosseous recurrent behind; about the internal condyle the superior and inferior ulnar collateral arteries descend, uniting with the volar and dorsal ulnar recurrents. The inferior ulnar collateral also sends an arch across above the olecranon, uniting with all the other vessels on the dorsal surface of the elbow.

*Nerves.*—The *median nerve*, having crossed the brachial artery above at a very acute angle, lies in this region at its medial side, usually separated from it by a slight interval. It then passes deeply between the two heads of the pronator teres, the coronoid head separating it from the division of the brachial and the ulnar artery, and finally leaves the region of the elbow and gains the middle of the forearm by passing under the arch of the flexor digitorum sublimis. The motor branches of the median nerve are all given off at or near the elbow. Sometimes all the branches for the forearm are derived from a common trunk which then might be known as the deep median nerve (*N. profundus medianus*, Schwalbe). The usual arrangement, however, is for three nerves to separate in succession: (1) one that supplies the humeral head of the pronator teres, given off a little before the nerve passes under the lacertus fibrosus; (2) a trunk for the superficial muscles of the forearm, given off between the two heads of the pronator teres and including a branch for the coronoid head of that muscle; (3) a trunk for the deep muscles of the forearm, usually given off between the pronator teres and the flexor digitorum sublimis.

The *radial nerve*, after winding around the humerus from behind, reaches the region in front of the elbow a short distance above the condyles, by perforating the lateral intermuscular septum. It then lies at the bottom of the lateral bicipital groove, against the fibers of the brachialis which separate it from the joint capsule, and between the brachioradialis and the biceps. It divides, usually at the level of the articulation or slightly above it, but sometimes as far down as the head of the radius, into superficial and deep branches which lie in contact with the capsule of the elbow joint. The radial recurrent artery often lies in the angle of bifurcation. The deep branch, exclusively motor, leaves this region by perforating the supinator muscle and thus reaching the back of the forearm. The radial proceeds distally under cover of the brachioradialis lying lateral to the radial artery.

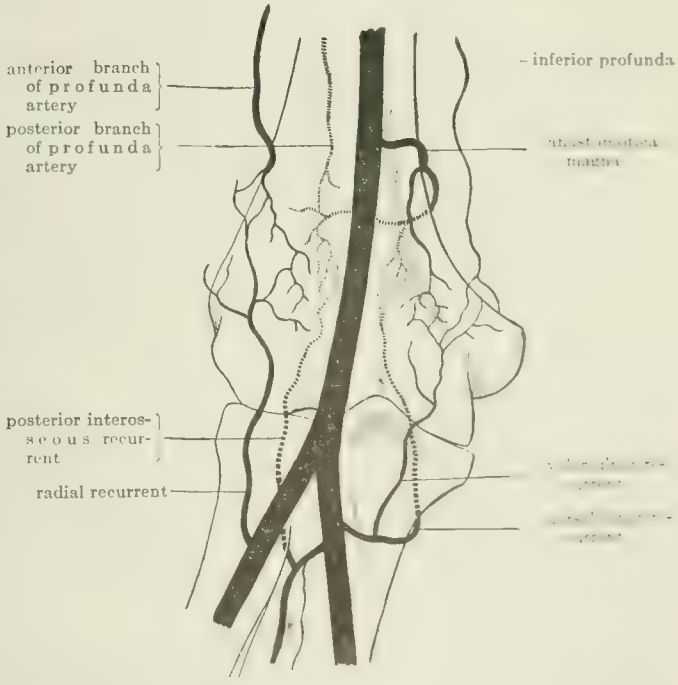



Fig. 1950.—Anastomosis of Arterial Branches about the Elbow.

Behind the elbow the muscular mass is composed of the triceps and the anconæus, its continuation upon the lower arm. The portion of the *triceps* that comes properly within this region is its insertion, which consists, first, of a thick, firm, aponeurotic expansion which receives fibers from all the heads and is inserted upon the proximal surface and lateral edges of the olecranon; second, of fibers from the lateral and medial heads that are implanted without any intermediary tendon directly upon the olecranon.

Below and laterally the triceps blends intimately with the *anconæus*, there often being no appreciable interstice between them. This continuity and its supply by the same branch of the radial nerve that innervates the medial head of the triceps, have led some to the conclusion that the anconæus should be considered as a fourth head of the triceps. It radiates fan-like from a short and strong tendon attached to the dorsal and distal portion of the external condyle, its fleshy fibers being inserted by direct implantation into the side of the olecranon and over the entire extent of the excavated dorsal surface of the ulna that lies above the oblique line.

At the sides of the elbow the muscular masses are arranged in two groups, quite distinct in their origin, function, and innervation. The inner group arises from the medial epicondyle or near it, contains pronators and flexors, and is innervated by the median and ulnar nerves; the outer group arises from the lateral epicondyle and the epicondylar ridge above it, contains supinators and extensors, and is innervated by branches from the radial nerve.

Some explanation of the peculiarities of these lateral muscles is afforded by the history of the development of the arm. In the fetus each limb arises as a bud-like outgrowth from the trunk, and is covered by a prolongation of the ventro-lateral common muscular sheet. As it increases in length this prolongation becomes segmented near the elbow into a pronato-flexor mass and a supinato-extensor mass. In lower animals, like reptiles, that have no independent movements of the different parts of the hand, these masses remain in their primitive condition, but in those that have a variety of movements for the hand, the masses become split into layers and finally into distinct muscles. Irregularities in this process cause numerous varieties. In adult man traces of the primitive con-

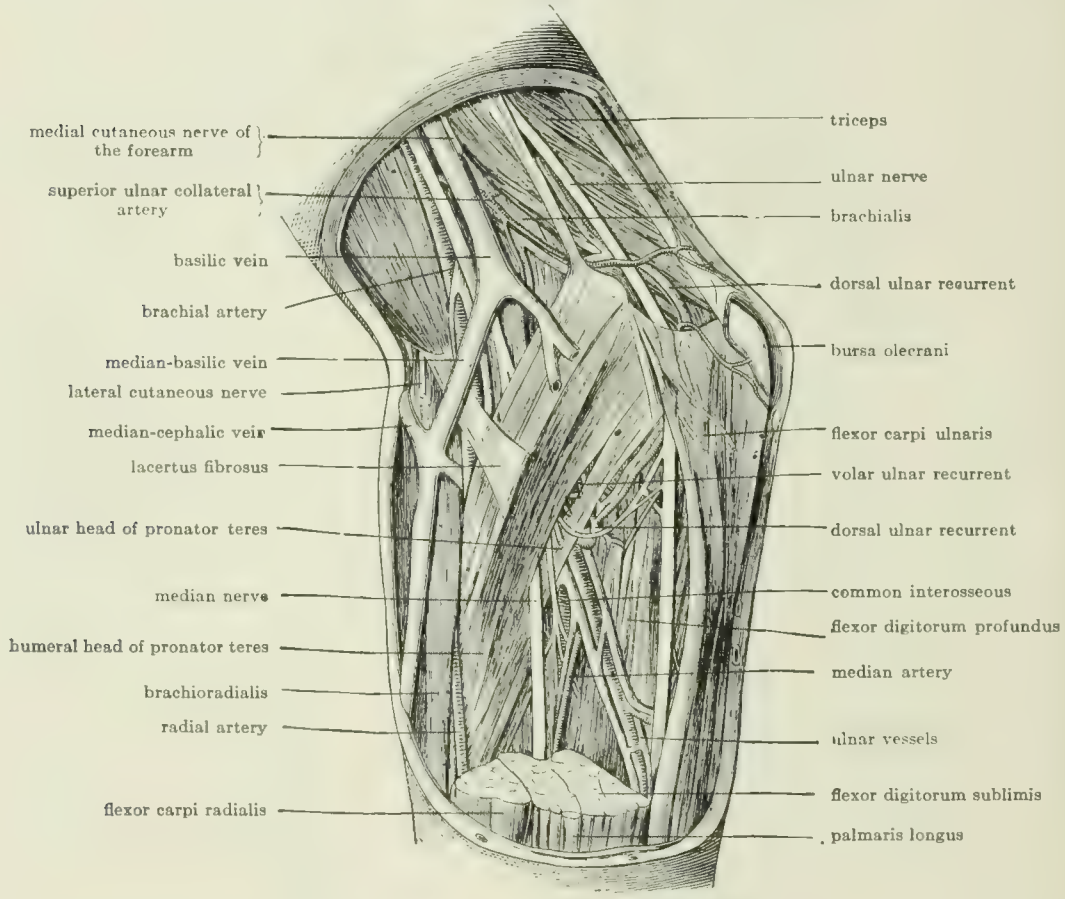



Fig. 1951.—Dissection of the Elbow from the Medial Side.

dition persist at the place of origin of the muscles, many of which continue to spring from an undifferentiated mass, or, as it is styled, from a common tendon.

The muscles of the pronato-flexor mass found in the region we are considering are the pronator teres, the flexor carpi radialis, the palmaris longus, the flexor carpi ulnaris, and the flexor digitorum sublimis. The first four of these form a superficial layer, while the flexor sublimis constitutes a layer by itself (see Fig. 1951).

The pronator teres lies farthest to the radial side and therefore forms the medial boundary of the cubital fossa. Besides its origin from the medial epicondyle it has a slip attached to the coronoid process of the ulna. Between these two slips of origin passes the median nerve as already mentioned.

The *flexor carpi radialis* and the *palmaris longus*

have no special anatomical importance in this region, merely arising from the medial epicondyle by the common tendon and presenting spindle-shaped masses lying approximately parallel to the pronator. The flexor carpi ulnaris arises by two heads, one from the medial epicondyle by the common tendon, one from the olecranon and the proximal two-thirds of the crest of the ulna. These heads are united by a fibrous arcade under which pass the *ulnar nerve* and the dorsal ulnar recurrent artery. The nerve descends behind the medial intermuscular septum, accompanied by the superior ulnar collateral artery which lies in front of it, enters the shallow groove behind the medial epicondyle, sometimes held in place by a slight elevation of bone arising from that process. It is here in close relation with the ulnar collateral ligament of the elbow-joint, which throws over it a fibrous investment which, according to Sutton, is the remains of an atrophied muscle, the epitrochleo-anconæus, rarely found in man but common in apes. These fibers help to fix the nerve and prevent it from slipping from its groove, a common accident in dislocations. During flexion the groove widens somewhat owing to the slight lateral displacement of the humerus. A small bursa often lies between the nerve and the bone, necessitated by the movements of the nerve during flexion and extension. In this situation the nerve is almost subcutaneous, crossed by branches from the medial cutaneous nerve of the forearm, and as it lies against an unyielding surface it is particularly subject to shock when the medial edge of the elbow is struck. This has led to the designation of its locality as the "funny bone." It is mainly on account of the presence of the nerve on this side that the joint is opened from without in operations for resection.

The *flexor digitorum sublimis* has a threefold origin, one by a thick and strong slip from the medial epicondyle and the ulnar collateral ligament by the common tendon, another from the medial border of the coronoid process and a third by a broad and thin lamina from the oblique line and volar border of the radius. The ulnar and the radial heads bound an oval foramen through which pass the median nerve and the ulnar artery.

The muscles of the supinato-extensor mass found in this region are divided into two groups: a lateral one, comprising the brachioradialis, the supinator and the two radial extensors of the wrist; and a dorsal one, comprising the common extensor of the fingers, the extensor of the little finger, and the ulnar extensor of the wrist. The ulnar crest separates these groups from the pronato-flexor muscles.

The *brachioradialis* is the most superficial of its group, arising from the proximal two-thirds of the lateral supracondylar ridge of the humerus and from the lateral intermuscular septum, and extending down along the lateral side of the forearm to which it imparts its characteristic shape. The muscle is drawn forward by the deep fascia of the forearm and forms the lateral boundary of the cubital fossa. Above the elbow it lies upon the radial nerve and the radial recurrent artery, below upon the radial vessels and nerve. Its usual office is that of a flexor of the forearm, it acting as a supinator only when the arm has been previously strongly pronated.

Closely connected with the brachioradialis at its origin is the long radial extensor of the wrist, for its fibers immediately succeed those of the former muscle upon the lateral supracondylar ridge, here somewhat enlarged, extending down for about an inch, or to the base of the epicondyle. It is partly covered by the brachioradialis and is in contact with the proximal part of the capsule of the joint.

Lying directly under the foregoing and arising from the volar surface of the lateral epicondyle is the short radial extensor of the wrist. The two muscles are not infrequently interblended in various ways.

The *supinator* lies deeply under both of these, a bursa usually intervening, and close against the joint capsule. Arising from the distal part of the lateral epicondyle and the common tendon, also from the interosseous border of the ulna and the excavation below the radial notch of the ulna, its fibers run spirally from above downward and laterally and are inserted around the proximal third of the radius, embracing the neck and reaching the tuberosity and the oblique line. It adheres closely to the radial collateral and annular ligaments of the elbow-joint. The muscle is divided into two planes of fibers between which passes the dorsal interosseous nerve. It shares with the biceps the function of supinating the hand and arm by rotating the radius.

The muscles of the dorsal region of the proximal forearm radiate from the lateral epicondyle just below the anconæus. The common extensor of the fingers is the most external of these, appearing in this region as an undivided pyramidal mass arising from the distal and volar portion of the epicondyle and the common tendon. It is in contact with the radial collateral ligament and the supinator and wedged between the short radial extensor and the ulnar extensor.

Interposed between the common and ulnar extensors and seemingly differentiated from the former is the extensor of the little finger. It arises mainly from the fascia of the forearm and the septa that lie between it and the two contiguous muscles. In about four per cent. of cases its muscular belly is indistinguishable from that of the common extensor.

The ulnar extensor of the wrist runs diagonally across the back of the arm from the lateral epicondyle to the ulnar side. It arises from the lower and posterior portion of the epicondyle and the common tendon, from a strong intermuscular septum that springs from the proximal three-fourths of the crest of the ulna and from the fascia of the forearm. A bursa is often found beneath its condylar tendon, often extending also beneath the origin of the common extensor.

Elbow-joint.—In this important joint there are united in a single capsule three articulations: one between the humerus and the ulna; one between the

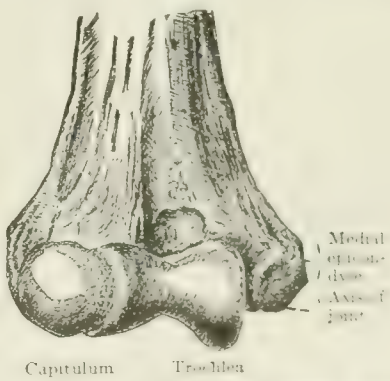



Fig. 1952.—The Distal End of the Humerus, showing the Articular Surface.

humerus and the radius, and one between the ulna and the radius. This diversity of union permits a great variety of motions for the forearm and hand and determines largely the distinction that exists between the upper and the lower extremity. Thus there is produced by this means an angular motion of great steadiness by which the forearm is flexed and extended, and also a motion by which the radius and ulna are altered in their relations, being made to turn over each other across their long axes, and thus rotate the attached hand. Movement of this kind toward the median line, turning the palm downward, is termed pronation; in the opposite direction, turning the palm upward, supination.

The humero-ulnar articulation gives the whole system solidity, its strength being due to the configuration of the articulating surfaces, and the peculiar arrangement of the ligaments.

The humerus presents at its distal end a surface curved like an Ionic volute, and grooved like a pulley, which gives it its name of trochlea (see Fig. 1952). The surface is obliquely directed, and the groove is not quite symmetrical, but has a slight lateral twist. On this surface the ulna glides, embracing it by the

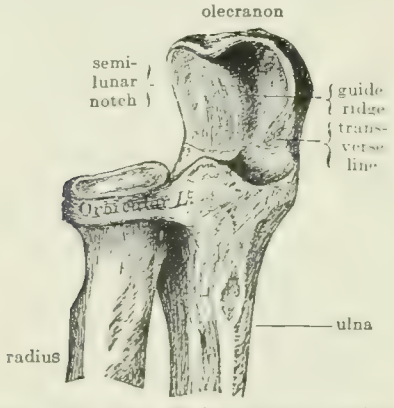



Fig. 1953.—The Proximal End of the Radius and the Ulna, showing the Articular Surfaces.

gap between the olecranon and the coronoid processes known as the semilunar notch (see Fig. 1953), not quite a semi-circumference, the olecranon passing up behind into the fossa of that name in the humerus when the arm is extended, and the coronoid process similarly fitting into its appropriate fossa in front during flexion (see Fig. 1954). The coronoid and olecranon portions of the ulnar surface are separated by a transverse line devoid of cartilage (see Fig. 1953), corresponding to the place where the epiphysis unites with the shaft. The whole olecranon process is a secondary growth, as in fetal life the joint begins its development as a simple slit between two ends of bone which are apposed very much as the ends of the finger bones are in the adult. At birth the process is not completely developed, and the olecranon and coronoid fossæ of the humerus are not so deep as they are in the adult. It is interesting to note that in renewal after resection the fetal conditions reappear, the ulna not usually acquiring an olecranon, but resembling more the upper end of the tibia. The transverse line above mentioned is crossed at nearly right angles by a guide ridge which fits into the deepest part of the trochlear groove. The direction of this is not quite the same in the two portions, and a piece cut from the olecranon or coronoid process will not exactly fit all parts of the trochlea. There is usually, therefore, a slight deviation or lateral wabbling of the joint in flexion and extension, which is not, however, sufficient to be noticeable without instrumental measurements. The results of tracings made by points carrying ink are shown in Figs. 1955 and 1956, the two lines there drawn on the trochlea being tracings of points attached to the coronoid and olecranon processes, respectively. The curves bend and return into each

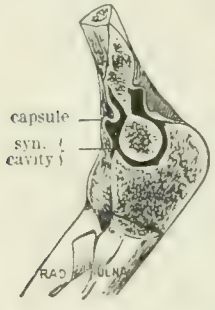



Fig. 1954.—A Sagittal Section through the Elbow-joint, showing the Adaptation of the Articular Surfaces, and Folds of the Capsular Ligament.

other, so that, though there is a slight lateral working, it is readjusted before the end of the course. This may be easily demonstrated by observing, during flexion and extension, a spot of ink placed on the most prominent point of the olecranon. By carefully sighting this with a vertical thread, it will be seen to move laterally. It may also be demonstrated by making a vertical section through the extended joint, and then flexing, when the cut surfaces of the bones will be seen to ride past each other. It appears, then, that there is a slight interval between the articular surfaces at the sides, only the guide ridge remaining

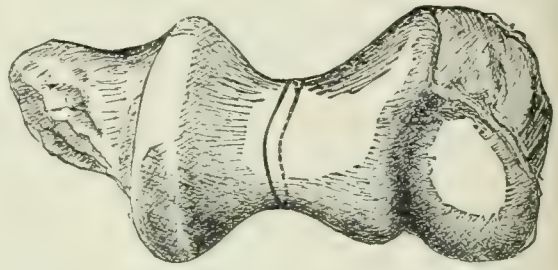


Fig. 1955.—The Trochlear Surface of the Humerus, showing Tracings of the Paths of the Olecranon and Coronoid Processes of the Ulna during Flexion and Extension. (After Braune and Kyrklund.)

constantly in contact. The joint cannot, therefore, be said to be a perfect hinge, although it may be so regarded for all practical purposes.

External to the trochlear surface of the humerus, and separated from it by a shallow groove, is a rounded portion about as large as an ordinary marble, called the capitulum or radial head (see Fig. 1952). It does not extend far back, but looks directly forward, and the button-like head of the radius which articulates with it can be felt behind, moving from side to side when the extended arm is supinated. This is an important assistance in diagnosticating dislocations and other injuries here. The head of the radius is in contact with the capitulum only when the forearm is flexed at right angles; during complete extension its anterior edge touches but its posterior half is entirely free. The shallowness of the depression by which the radius fits would make the joint very insecure, were it not that that bone is bound sidewise to the ulna by a

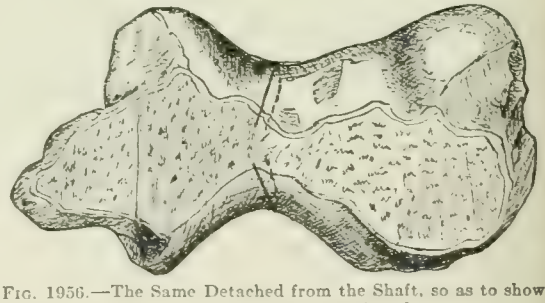


Fig. 1956.—The Same Detached from the Shaft, so as to show how the Paths meet if continued.

strong band called the annular ligament (see Fig. 1953), articulating in a shallow depression called the radial notch. The broadest part of the radial rim fits this, in the position of the arm which is most usual, viz., that of semi-pronation. The rim passes a little beyond the radial notch and just touches the bevelled edge which separates the capitulum from the trochlear portion of the humerus, rolling upon it in pronation and supination. The combinations of flexion with pronation, and of extension with supination, are therefore in accordance with the nature of the articular surfaces. The line of the articulation

is oblique, and in amputating it is useful to remember that it lies about three-eighths of an inch below the lateral epicondyle and one-fourth inch lower on the medial side. The head of the radius, which can be felt as mentioned above, is the best guide to it.

From the configuration of the surfaces here described, it will be noticed that lateral luxations must be rare, the dislocation outward being easier than in-

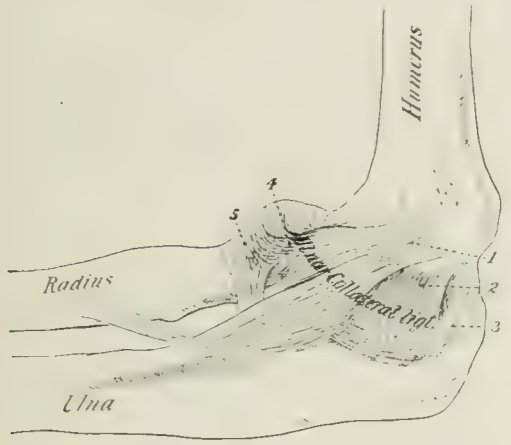



Fig. 1957.—View of the Ligaments of the Elbow-joint from the Inner Side. 1, Band extending from the epicondyle to the tuberosity of the coronoid process; 2, radiating bundles from the epicondyle to the border of the semilunar notch; 3, arciform fibers which pass forward from behind and protect the ulnar nerve; 4, oblique band which passes to the head of the radius, blending with 5, the annular ligament of the radius.

ward; that anteroposterior luxations are easier and can be effected in any position of the joint, the posterior one being necessarily the most common. When a single bone is dislocated it must be the radius.

A fibrous capsular ligament lined with synovial membrane invests the joint. Above and below it is attached beyond the articular surfaces of the corresponding bones, the head of the radius being, as it were, stuck through a slit in it. Being quite loose, to admit of extensive movements (see Fig. 1954), it

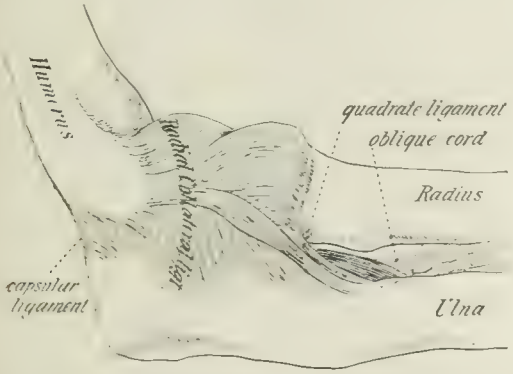



Fig. 1958.—View of the Ligaments of the Elbow-joint from the Lateral Side.

would be nipped in front and behind during flexion and extension, were it not held out of the way by the flexor and extensor muscles which blend intimately with it. It is further protected by a pad of fat in each fossa, and over this the muscles pull. The capsule is thinner behind than in front, and an effusion into the joint cavity first shows there, on either side of the olecranon and the tendon of the triceps.

In certain situations the capsule is strengthened by accessory bands, which have received special names. The strongest of these are the collateral ligaments, which radiate from points on the humerus which are approximately in a line with the axis of rotation, and some of their fibers are therefore tense in every position of the joint. They are important sustainers of the articulation—indeed, if they are intact the anterior and posterior portions of the capsule may be removey without affecting the security of the joint. Thed also prevent the coronoid and olecranon processes from quite reaching the bottom of their respective fossæ in the humerus, which might cause chipping of the bone.

The ulnar collateral ligament (Fig. 1957) presents several small bundles, which radiate to the coronoid process and the medial border of the olecranon. In front it is intimately blended with the origin of the flexor digitorum sublimis; behind it forms, together with some arching fibers and the tendon of origin

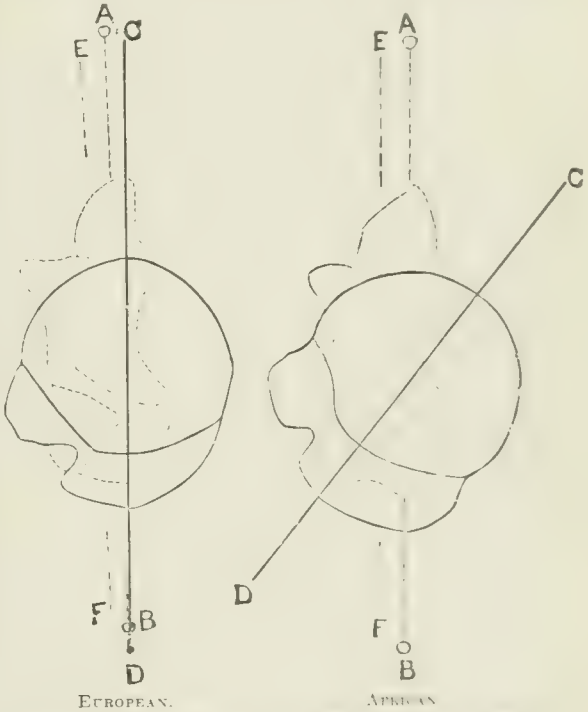



Fig. 1959.—Inclination of Axis of Elbow-joint to the Frontal Plane of the Body. *A B*, Line drawn through the condyles of the humerus; *C D*, line drawn through the [illegible] surface of the head of the humerus; *E F*, axis of elbow-joint. (After Welcker and Lucæ.)

of the flexor carpi ulnaris, a smooth groove for the ulnar nerve, which lies so closely on the ligament that it cannot be divided here without risk of opening the joint. In forced extension, caused by violence, the ulnar collateral ligament is always ruptured or injured, and the bones are fractured in some manner. The volar band of the ligament appears to check pronation, as it is ruptured when this movement is violently performed. In forced flexion the dorsal band is frequently torn. In fracture of the olecranon this ligament often prevents separation of the fragments.

The radial collateral ligament (Fig. 1958) blends in front with the supinator, the tendon of origin of that muscle being, in fact, a part of it. Below, it unites with the annular ligament, sends a strong band to a tubercle below the radial notch of the ulna, and adheres to the medial edge of the olecranon. In

forced movements (except adduction) this ligament does not usually give way until others are ruptured. The middle band is especially strong, and may tear a piece off the bone before parting. If the annular ligament is broken, the supinator and the biceps pull the radius out of its socket. As this bone is more loosely attached than the ulna, the accident is not infrequent, being usually caused by falls on the pronated hand, or, in young children, by a strong jerk on the arm.

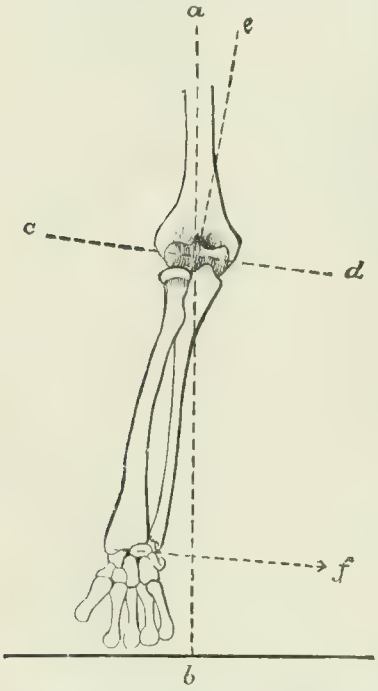



Fig. 1960.—The Bones of the Right Arm in Extension and Supination. *a*, *b*, Axis of humerus; *c*, *d*, axis of motion of elbow-joint; *f*, the plane in which the styloid process of the radius moves in pronation and supination.

The annular ligament is considerably more elastic in children. A band, sometimes described as the quadrate ligament, usually passes from the lower border of the radial notch to unite with the annular ligament (Fig. 1958). Ordinarily relaxed, it limits pronation and supination.

The synovial membrane is large, and contains numerous deposits of fat, which are especially abundant in front and behind.

Flexion and extension may, as stated above, be considered for practical purposes as occurring in a single plane which is not parallel with the median plane of the body, but is directed obliquely, so as to carry the hand toward the mouth. This results from the fact that the axis of rotation of the joint is not at right angles to the long axis of the humerus, but makes with it an angle of some twenty degrees (see Figs. 1958 and 1960). This obliquity does not occur in the fetal joint, and is less marked in the lower races of men and in the anthropoid apes. In them ease of bringing the arm across the body is effected by an obliquity of the trochlear axis to the frontal plane. This can be measured by noting the inclination of the trochlear axis to a line drawn through the axis of motion in the head of the humerus. Careful measurements made by Welcker, Lucæ, Gegenbaur, and Schmid show that this angle averages about sixteen degrees in Europeans and thirty-two degrees in negroes and Malays (see Fig. 1959).

In the fetus the angle is about forty-three degrees, and in a child of one year about thirty-eight degrees. It would appear from this that the humerus has undergone a twisting about its long axis to bring the palmar surface of the hand forward, and thus make it more useful as a prehensile and tool-using organ, and that this is more complete in the higher races. When this torsion becomes nearly complete it would make it difficult to carry the hand across the body, were it not compensated for by the inclination of the trochlear axis which proceeds *pari passu* with it.

As a result of this inclination the arm and forearm make, in extreme extension, an outwardly directed angle of about 165 degrees. This is most marked in supination, and almost entirely disappears on pronating the hand. It is therefore best, when applying extension to the humerus by pulling the hand, first to effect pronation. When the muscles are relaxed the force of gravity necessarily carries the hand into a semi-prone position with the thumb to the front. The attitude of "attention" prescribed by tactics for a soldier, *i.e.* with the palm forward, is therefore a forced one.

When a body like a ball is grasped by the hand and thrown by suddenly extending the arm, the inclination of the axis of the forearm causes it to be sent obliquely unless this is counteracted by strongly pronating the forearm. This pronation is the so-called "twist" of baseball pitchers. In performing it the limb is slightly lengthened. This may be demonstrated by standing so as just to touch a horizontal table with the end of the index-finger in pronation and then supinating the hand, when the finger will be found to rise about three-eighths of an inch. The mechanism of this will be apparent on inspecting Fig. 1960, which shows that the plane *f*, in which the distal end of the radius moves, is oblique to the plane of the table.

Pronation and supination involve not only the movements of the bones in the proximal radio-ulnar articulation, but also the movements of the radius and ulna at the wrist. Anatomists have been divided in opinion as to exactly what part is taken by each bone in this motion. By far the greater number have held, with Galen, Vesalius, and Albinus, that the ulna can take no part in the movement, being incapable of lateral motion at the elbow. The prevailing view is illustrated in Fig. 1961, which represents the usual method of articulating the bones for class demonstration. A fixed axis passes through the head of the radius above and the head of the ulna below, so that the radius flaps back and forth around this in a way that may be rudely expressed by two boards obliquely hinged together (Fig. 1962).

Fig. 1961.—Usual Method of Illustrating the Movements of Pronation and Supination. The radius and ulna joined together by means of a rod passing through the head of the radius and the head of the ulna.

It is rather strange that the absurdity of this view has not been more generally seen, especially as a movement of the ulna was recognized by Winslow, Monro, and Vicq d'Azyr, the latter anatomist demonstrating it by the impression which the rotating hand left in a bed of clay.

Cruveilhier (following Bertin) declared this movement to be only apparent, and that by stripping off the muscles from the shoulder down and fixing the humerus, the immobility of the ulna could be demonstrated. The general treatises on anatomy have copied this statement with great docility, only a few investigators insisting, notwithstanding the weight of authority, that the ulna actually does move. Among these is Duchenne, who, by observing the movements of the end of a style fixed transversely upon the ulnar prominence of his own wrist, declared that the distal extremities of the radius and the ulna describe semicircles equal in extent and opposite in direction. Lecomte showed that by fitting an inextensible ring

around the wrist above the styloid processes the movements of pronation and supination could still take place, which would not be the case were the radius alone active. He believed the ulna to be capable of circumduction, and pointed to the multiple facets in the sigmoid cavity as being proof that there is a riding from side to side. He compared the bones of the forearm to two parallel revolving axles (arbres), supporting and pivoting upon each other with their extremities united by very movable articulations. The ulna has a pronator, the anconæus, and a supinator, the pronator quadratus. This latter muscle shows, by its attachment wrapping around the shaft of the ulna, that it is intended to roll that bone toward the radius.

Fig. 1962.—The Same Mechanism Illustrated by Pieces of Board Hinged Together. (After Welcker.)

Later observers have pointed out that, as Lecomte discarded all experiments on the cadaver, he could not have been sure that he fixed the humerus, and that consequently many of his results arise from the slight rotation of the humerus which usually accompanies pronation and supination. The ring causes forced and unnatural movements. A mathematical calculation shows that the action of the pronator quadratus must vary according to the situation of the axis around which the bones turn, and may be in one direction or the other, as that axis varies.

In 1883 Heiberg published the results of some investigations made by him on the cadaver, which seemed completely to confirm Lecomte's views. Disarticulating at the wrist, he inserted into the radius and the ulna stiff rods, at the end of which were brushes charged with ink. It was necessary to use brushes, as the motions described were not in a single plane. On effecting movements of pronation and supination, these brushes described on paper curves which are approximately shown in Fig. 1963.

That for the radius is rather flat and appears to be a portion of a cycloid, while that for the ulna is smaller and is nearly an arc of a circle. In order to ascertain if similar results could be obtained in the living subject, he strapped a metal rod firmly to the arm along the edge of the ulna, carrying it out beyond the olecranon process so far that the distance between the distal edge of the semilunar notch and the end of the rod should be approximately equal to the distance between the same point and the styloid process of the ulna.

This proximal end he found to describe curves which were similar to those described by the distal end in the cadaver, and he therefore concluded that the ulna describes movements of circumduction during pronation and supination, the distal portion generating a conical surface and the proximal portion another, the vertices of the cones meeting at the distal edge of the semilunar notch. He presented his views to the International Medical Congress in 1884, and a lively discussion ensued. It was pointed out that his apparatus must necessarily produce very inexact results. Since that Cathcart has stated that in patients who have ankylosis of the humerus at the shoulder-joint he finds pronation and supination to be difficult, and Flesch found that in an apparatus rigged to imitate the elbow-joint the movements of the ulna appeared to be mainly those of flexion and extension. In the living subject the anconæus strongly contracts during pronation, and the brachialis and flexor carpi ulnaris during supination.

My own experiments completely confirm this. The most important paper that has recently appeared has been one by Braune and Fischer, who made, during 1885, a series of most careful experiments on the cadaver, in order to establish the character of Heiberg's curves of movement. The cadaver used was that of a suicide, and quite recent. The motions were induced by weights and pulleys acting as nearly as possible in the line in which the muscles pull during life, and pains were taken not to force them by making the weights too heavy. Styles were inserted firmly into the ulna and radius, and the path described by their ends was carefully observed and traced upon glass in at least two planes, or marked by reflecting mirrors on a wall. From the tracings, a system of coordinates was obtained by which the path of each

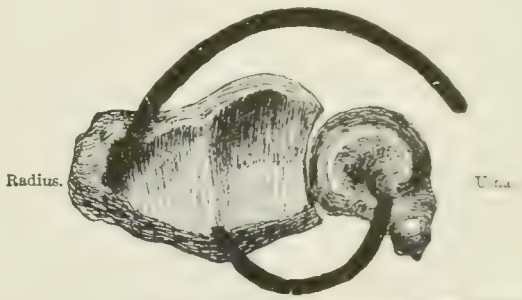



Fig. 1963.—The Lower Ends of the Radius and Ulna, Showing the Movements of Pronation and Supination. (According to Heiberg.)

style was calculated. It was found that the paths described by the ulna belonged to no regular curve, but were a series of motions of flexion and extension, with a slight degree of lateral motion.

These results agree with experiments which I have myself made on this subject, but it should be added that the amount of ulnar movement undoubtedly varies considerably according to circumstances, and that the axis of motion, instead of being fixed, as usually stated, changes according to the act performed.

Frank Baker.

**Elecampane.**—See *Inula*.

**Electric Batteries.**—By the term electric battery is usually understood a serial connection of voltaic cells, though a single cell may be spoken of as a battery; other types of electric battery exist which will be discussed below.

Galvanic Batteries. A voltaic cell consists of a pair—two plates or objects of other configuration composed of substances of different electric conductivity—and a fluid known as the electrolyte, which both conducts electricity and is decomposed by it. To select a concrete example let us suppose two plates of zinc and carbon immersed in a jar containing aqueous solution of sal ammoniac. Some chemical activity is at once set up between the zinc and the solution, so that ordinarily the two plates must be kept suspended above the solution. For the generation of electromotive force a circuit must be formed by joining the two plates by a metallic wire after they have been lowered into the solution. The chemical activity is now resumed and simultaneously an electric current passes through the circuit the force of which can be measured in volts. The zinc element constitutes the positive, the carbon the negative pole. The zinc and ammonium chloride unite to form zinc chloride while ammonia and hydrogen are set free. The ammonia remains in solution while some of the hydrogen collects upon the carbon plate and therefore tends to interfere with the passage of the current by increasing the internal resistance, or causing polarization.

In theory one battery of this type might differ but slightly from another employing plates of other kinds of metal and a different electrolyte. Why is it then that as many individual forms of voltaic cell exist? These are all based upon attempts at lowering the internal resistance and increasing voltage, or on financial considerations, or on efforts to secure cells best adapted to certain demands upon them.

*Double* or *two-fluid cells,* containing two different electrolytes have been devised to do away with polarization. The more common method is to introduce into a single cell certain powerful oxidizing agents (binoxide of manganese, cupric sulphate, etc.) with which to protect the carbon or whatever negative element is used.

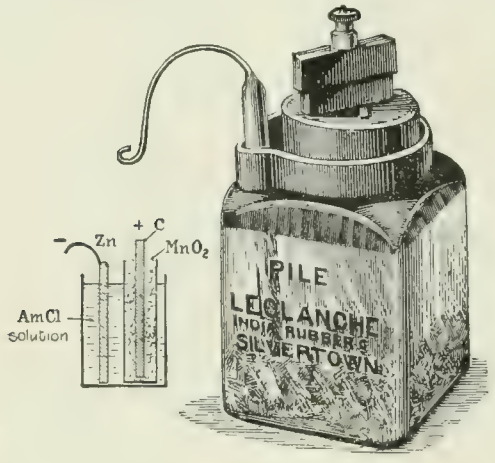



Fig. 1964.—Leclanché Cell.

Whatever the negative element zinc is very commonly used for the positive pole, as it combines with a great number of acids and bases and is inexpensive. It is not ideal, however, for if too pure it is not readily attacked by the electrolytes, and if very impure it is rapidly used up.

So-called *dry cells* are in reality moistened cells and are of the simplest structure. The elements are zinc and carbon, the latter surrounded by black oxide of manganese to oxidize the hydrogen which accumulates at the negative pole. The exciting fluid is usually chloride of ammonium, mixed with plaster of Paris or flour. The same substances enter largely into the formation of ordinary cells.

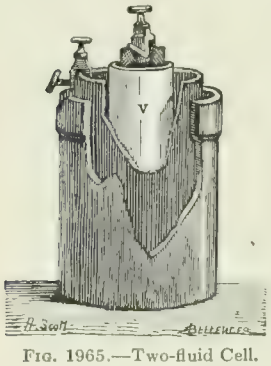


Fig. 1965.—Two-fluid Cell.

An ideal voltaic cell should have a high and constant E.M.F.; but two factors have always stood in the way, to wit: the polarization of the hydrogen against the negative pole—the alteration in the surface of the plate increasing the internal resistance, while the oxidation of the hydrogen produces a counter-current with the same results—and the short circuiting and corrosion of the positive element due in part to impurities. Considerable progress has been made in overcoming these obstacles.

We may consider in order some of the best known simple or single fluid cells. The one described in the introduction is known as the *Leclanché cell,* which, however, has been modified from its primitive form. The positive or zinc pole is represented by an amalgamated zinc rod while the carbon plate is surrounded by black oxide of manganese. The voltage is high—1.5.

The *Latimer-Clark cell* has as its positive pole a column of pure mercury covered with a layer of mercurous sulphate; negative pole a rod of pure zinc or an amalgam of zinc and mercury; electrolyte a saturated solution of zinc sulphate. The cell, which is sealed up to prevent evaporation, is used chiefly for standardization. Its E.M.F. is 1.434.

The so-called *zinc-carbon cell* consists of a zinc plate with a cluster of carbon rods; in this case the zinc represents the negative pole. The electrolyte is ammonium chloride solution. This cell gives a strong current (1.33) for a short time only but polarizes rapidly.

Fig. 1966.—Hellesen's Dry Cell.

In the *Lalande-Chaperone cell* zinc is the positive, copper or iron the negative element. The electrolyte is potassium hydroxide and the oxidizer at the negative pole cupric oxide. E.M.F. 1.98.

In the *Maische cell* the zinc of the positive pole is in the form of zinc scraps in mercury; at the negative pole the carbon plate is platinum coated. The electrolyte is sodium chloride solution and no special oxidizer is required. E.M.F. 1.25.

In the *Marie-Davy cell* the elements are zinc and carbon, the electrolyte dilute sulphuric acid while mercuric sulphate is used to dispose of the hydrogen. E.M.F. 1.52.

The *Maynooth battery* like the preceding is very simple in construction. The elements are zinc and iron, while dilute sulphuric acid is the electrolyte and nitric acid the oxidizer.

The *Niaudet* is also a zinc-carbon battery, the electrolyte a solution of common salt and chlorinated lime used as oxidizer. E.M.F. 1.63.

The *Poggendorf* is another zinc carbon, the electrolyte a solution of potassium bichromate in dilute sulphuric acid, while chromic acid is the oxidizer. The E.M.F. is 1.98.

The *De la Rue* is a zinc-silver battery, electrolyte solution of sal ammoniac. Silver chloride is used to dispose of the hydrogen (by reduction), colloid silver being formed.

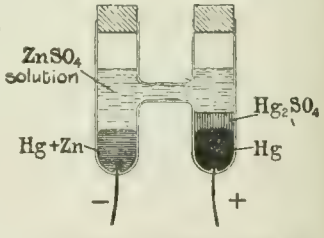



Fig. 1967. -The Latimer-Clark Cell.

The *Schanschieff* is a very simple cell—zinc carbon with a mercurial electrolyte and without an oxidizer. The E.M.F. 1.56.

The *Scrivanoff* is a zinc-carbon cell, electrolyte potassic hydroxide, preventer of polarization silver chloride, as in the de la Rue cell. E.M.F. 1.5.

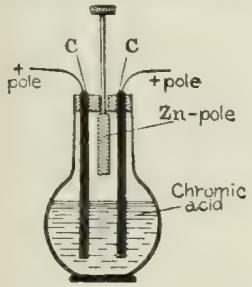
The *Smee* is an old, primitive type. Zinc and platinized silver the elements, dilute sulphuric acid the electrolyte, and without an oxidizer. E.M.F. low.

The *Walker cell* is composed of zinc and platinized carbon elements, with dilute sulphuric acid as electrolyte and no oxidizer. E.M.F. low.

The *silver chloride cell* has a zinc-silver pair, electrolyte dilute ammonium chloride. The silver element is covered with fused silver chloride to prevent polarization. E.M.F. 1.03.

The *Grenet bichromate cell* has a zinc plate between two carbon plates, the three being immersed in chromic acid and water or a saturated solution of potassium bichromate containing 10 per cent. of sulphuric acid. As the chromic acid attacks the zinc even when the circuit is open, the plate must be raised out of the solution when the battery is not in use.

There are also numerous varieties of *double fluid*



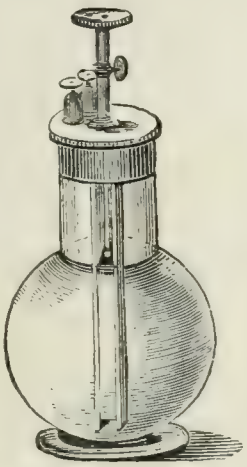



Fig. 1968.—Grenet Bichromate Plunge Cell.

batteries, some of which do away with the necessity for special substances to dispose of the hydrogen at the negative pole. The fluids are both electrolytes.

To take one of these, the *Grove cell*, as a model, we find its structure and mechanism as follows: the positive pole is a platinum rod dipped in a vessel containing strong nitric acid; the negative pole is a zinc plate dipped into ten-per-cent. sulphuric acid. Hydrogen given off at the platinum pole is at once oxi-

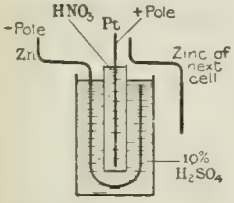
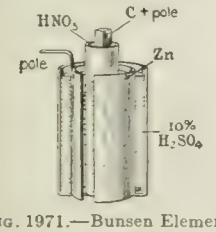


Fig. 1969.—Grove Cell. Fig. 1970.—The Partz Gravity Cell.

dized by the nitric acid; but the nitrous acid fumes given off at the same time lower the efficiency of the cell which has normally a voltage of almost 2.00.

A special type of double fluid battery is the *gravity cell*, so termed because one fluid is dense, and lies at



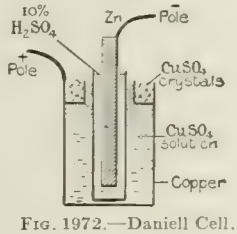




Fig. 1971.—Bunsen Element. Fig. 1972.—Daniell Cell.

the bottom of the jar while the other is light and supernatant. In the original "blue stone cell" the positive zinc element lies at the bottom in a dense solution of copper sulphate while the negative copper element lies in the lighter solution of zinc sulphate.

The *Partz gravity cell* is a zinc carbon. The electrolytes are, respectively, solution of sodium chloride to act upon the zinc above while the carbon element lies below in a ten-per-cent. solution of sulphuric acid in bichromate solution.

The *Bunsen cell* is not of the gravity type. The negative pole is a cylinder of zinc in ten-per-cent. sulphuric acid; the positive a stick of gas carbon which placed in a porous cell is then immersed in

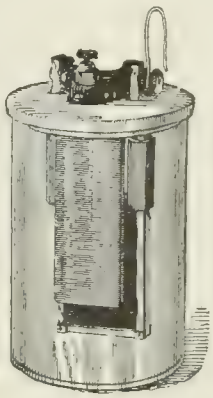


Fig. 1973.—Edison-Lalande Cell.

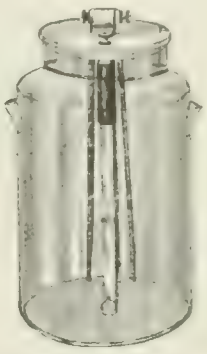


Fig. 1974.—Edison-Lalande Cautery Cell.

strong nitric acid. The escaping H is oxidized by the $HNO_3$ as in the Grove cell.

The *Callaud* is a gravity cell—zinc and copper elements with solutions of zinc sulphate and cupric sulphate as electrolytes.

The *Daniell* is of the ordinary type with the same elements and fluids.

The *Edison-Lalande* has zinc and copper elements; one electrolyte is used for both—solution of potassic hydrate. A plate of compressed cupric oxide in contact with the copper disposes of the hydrogen. For use in cauteries this cell is made with a large copper plate between two zinc plates, by means of which a very strong current is produced.

Storage Batteries.—Secondary or Storage Voltaic Cells. Ordinary or primary voltaic cells cease to generate when the positive plate or electrolyte is used

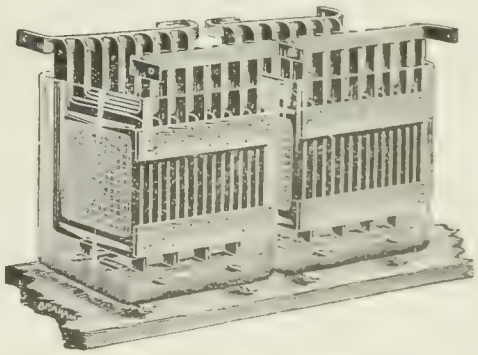


Fig. 1975.—Storage Battery.

up. When a storage cell is exhausted, it is possible to recharge it by passing a reversed current through it. The decompositions effected by this current restore the original status of the plates and electrolyte. Like primary cells the secondary cells occur in a variety of forms. As a rule the small plates of the battery are fitted into spaces within a large plate. This is made of lead alloyed with antimony to protect it from attack by sulphuric acid.

The arrangement renders the battery one large storage cell. The voltaic couple is usually porous lead (negative) and lead peroxide and the electrolyte dilute sulphuric acid. A storage battery connected with a number of primary galvanic cells is often used to form a cabinet battery. The rather feeble current of the primary cells is intensified by allowing it to accumulate in the secondary cells. The storage battery is usually charged with an ordinary current or dynamo. The ordinary electrolytic changes now occur until the current is shut off or the elements transformed. If now the two elements are connected with a wire, a current starts up in the reverse direction, and persists until the decomposed chemicals have reunited. The best-known storage batteries are the chloride and the Julien.

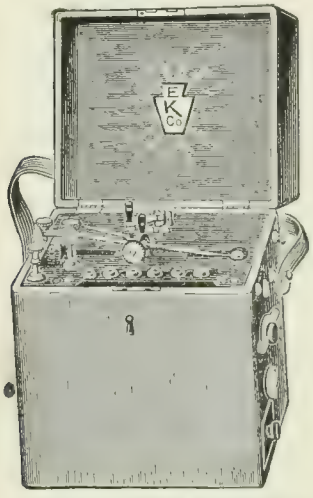


Fig. 1976.—Faradic Battery with Slow and Rapid Interrupters.

Faradic Batteries.—There are no faradic cells or batteries which are analogous to voltaic cells. Instead we speak of the faradic or medical induction coil. Wire intended to conduct an ordinary galvanic current is wound about a bobbin. Around this is a coil of finer wire, which either lies directly upon the primary coil or upon a hollow bobbin which slides along the first bobbin. When the galvanic current in the primary coil is interrupted or reversed a secondary or induced current is produced in the external coil. Induction coils occur in many modifications which, however, have to do chiefly with auxiliaries and do not affect the underlying principle. The nature and medical uses of the faradic current are described elsewhere.

Static Electricity.—In franklinic electricity Leyden jars may be formed into batteries by placing them in a box and coupling their inner coatings with brass rods, or by aligning them and causing their inner and outer coatings to join. The row of jars stands upon an insulating stand. The outer coating of the terminal jar must be in contact with the earth. The Leyden jars may therefore be termed cells—storage, but not generating cells. They condense electricity, being charged with the latter, usually negative electricity from an electric machine, which in turn attracts positive electricity from its environment. This stored electricity may be released by a discharger and then unite with the positive electricity with formation of a spark.

Edward Preble.

**Electricity: the Destructive and Lethal Effects of High-pressure Currents.**—There are delivered from the high-pressure* line of a big transmission plant, at night glowing blue with the energy that is streaming off into the dielectric, perhaps thousands of kilowatts to distant transformers, which may serve to light a whole city or furnish power to operate a street-railway system. The one result or the other obtains according to the conditions of the conducting circuit; but, in both instances, it is energy which is delivered at the terminals, and which by its expenditure produces the different phenomena instanced.

In the application of an electric current to the human organism, whether administered therapeutically, encountered accidentally in the pursuit of one's avocations, or applied with intent to kill (electrocution), energy is expended within the tissues of the body, causing physiological change, pathological lesion, or destruction of life. The phenomena produced, whether for life, disability, or death, depend not alone upon the initial pressure, but upon all the conditions of the conducting circuit, *i.e.* resistance electrical and vital, as well as position, superficies, and nature of contacts. A recognition of the oneness of this energy, whether of low or of high pressure, whether continuous or alternating in its direction, as well as the precise and definite laws under which it acts, conduces to an intelligent appreciation of the varying phenomena produced by its expenditure. A study of the action of an expenditure of energy from a high-pressure source or from a lower pressure, but capable under suitable conditions of producing injurious or destructive effects, involves an analysis of:

(1) Experiments made upon animals with a view to determine the cause of death;

(2) Such accidents as occur in the use of industrial currents;

(3) The phenomena observed in the electrocution of criminals.

Much experimental work has been done and many theories evolved as to the cause of death from electricity.

This goes back to the time of Nollet but it remained for Cunningham[1] and Prévost and Battelli[2] some two decades since to interpret the uniform action and set of conditions arising from a lethal dose of electricity.

Their conclusions have been verified and still further illuminated by the original experiments of Leduc in the production of electric sleep and anesthesia.

Under the second head the evidence is not so conclusive as in the first and third. In accidents due to electric currents—by reason of the fact that they are accidents and occur unexpectedly—the precise conditions of the conducting circuit, as well as the phenomena pertaining to the mechanism of injury or death, are rarely observed with scientific accuracy.

Under the third division—the electrocution of criminals—every opportunity is afforded to note exactly all the conditions of the conducting circuit, the pressure, the superficies, position and nature of contacts, the precise measurement of current in amperes, the time, the resistance, the power or watts, and the work or total expenditure of energy in joules. The opportunity also exists, if it could be taken advantage of, for obtaining definite, detailed, and scientific information as to how and when death occurs; as to consciousness and sensation; and also whether resuscitation would be possible by the immediate application of some special method; and it has been suggested that if the law recognized the right of science to have present a trained observer, with the privilege of using the necessary physiological apparatus in order to record graphically the phenomena which take place both during and after the passage of the current, as well as to make a careful study of the post-mortem findings, the result would be of incalculable value in determining the mechanism of death in man. There remains, however, no doubt as to the lethal effect of currents of high pressure as practised in electrocution.

What are the electrical conditions necessary to the production of injurious and lethal effects?

(1) What is to be understood by high-pressure currents in relation to lethal effects—*i.e.* what voltage is necessary to the production of fatal results?

(2) Is it a matter of pressure—*i.e.* volts alone, or is it a matter of current—*i.e.* amperes as well?

* In every instance in which authorities quoted have used the word "tension" in relation to an electric current, the writer has substituted "pressure" in order that the terminology may be exact.

(3) What influences the latter? the pressure only; or do high-pressure currents from position and nature of contact act as medium- or low-pressure currents?

An analysis of experimental work shows that currents of varying pressure have been used to produce a lethal effect in the same species of animals, while varying pressures are required for different species of animals.

Cunningham employed continuous currents from lighting mains of 115 volts pressure and from a battery of accumulators, 124 volts pressure, while Prévost and Battelli used both continuous and alternating currents, low pressure of 120 volts varying to a medium pressure of from 240 to 600 volts, and high pressures of from 1,200 to 4,800 volts. They used dogs, guinea pigs, rabbits, and rats, Cunningham dogs only.

With currents of high pressure, Prévost and Battelli found that 1,200 volts (the contacts being good—*i.e.* the one upon the head and the other upon the limbs) could kill all animals by inhibition of the respiratory center; but that the pressure of the current and the duration of the contact should increase with the size of the animal in order to inhibit the respiratory center. A rat, for example, succumbed to a pressure of 600 volts for one second, while a rabbit required 1,200 volts for two seconds. A dog of smallest size required 2,400 volts for three seconds, while a dog weighing eight kilograms resisted a shock produced by the passage of a current of 1,200 volts prolonged for five seconds. Nor is the pressure fatal to animals, when acting as a high pressure, necessarily fatal to man.

Of equal importance with the pressure are the position, superficies, and nature of contacts. The latter may be of a material which is a good conductor, but by reason of imperfect contact they may act as a poor conductor, thereby increasing the resistance and diminishing the amperes; the same will be true if the contacts are dry instead of moist. With the skin well wetted with salt solution the resistance is lessened; and with diminution of resistance there is an increase in the amperes. In such a condition of the skin a greater amount of current is delivered to the tissues, producing a fatal result; whereas, if the skin had been dry and able to perform its function as an insulator, the resistance would have been so great as to have limited the flow in current below the lethal dose. A well-insulated contact also serves to increase the resistance and to minimize the current.

The superficies governs the distribution of current on the one hand, or its current density on the other. With large square-inch area of contact, the greater the current diffusion; with small superficies the greater the current density, within a localized area. These are factors of great importance and must never be lost sight of when considering physiological effect.

The position of contacts is of the greatest importance and largely influences the result. All experimental work, as well as what is observed at electrocutions, proves that fatal results ensue much more quickly when the contacts are so placed as to bring the heart, which is the vulnerable organ, on a line which unites the two electrodes—*i.e.* directly in the conducting path; as, for example, on the head and calf of the leg. When they are placed on the head and fore legs, or in the case of man (electrocuted criminals) on the hands, a much greater pressure is necessary to destroy life. This is because the heart is not in the direct pathway of the current. When both contacts are placed upon the head, higher pressures are required to produce fatal results. Here, by reason of the skull, there is increased resistance; and, as the evidence shows that stronger currents, *i.e.* greater amperage (see Houston and Kennelly[3] pressure 690 volts, R. 1,200 ohms, current six amperes, dog not killed), are withstood, the pressure must of necessity be proportional. As will be seen further on, the action of the current is different in a head contact than when the heart is included in the circuit. These facts all point to the chest directly over the heart, and to the dorsal region, as the better places for the contacts in electrocutions; but, as it is desirable that consciousness should be annulled at once, the posterior contact could be made to include the cervical spine, medulla oblongata, and the head.

Duration of contact, or time, is another important element. An instantaneous contact with a high-pressure current may be encountered with impunity, but a fatal result will ensue if an application of several seconds—five, ten, or more—be made; or, if a high-pressure current be applied for an instant of time and repeated, fatal results may ensue.

As to the amperage of a lethal current, it is not definitely known, but all the evidence obtained from experiments on animals and accidents with industrial currents show that it is very small—probably much under one ampere. In the application of the death penalty as practised in the State of New York, the strength of the alternating current passed through the body of the criminal is usually seven or eight amperes. In experimental work, the species, weight, and age of the animal have influenced the result, and the age of man, as well as the vital resistance in both man and animals is a factor that must be considered in determining the lethal dose. In his experiments Cunningham found that young, well nourished, and hardy dogs bore a stronger current than those older and ill-nourished, but that the size and weight seemed to bear no relation to the minimum current.

The nature of the pressure, whether continuous or alternating, is not without its influence. Cunningham found that alternating currents of moderate frequency, intermittent and coarsely pulsatory currents, were able to produce fibrillary contractions of the heart much more readily than a non-alternating or a continuous current. Tatum found alternating twice as fatal as continuous currents, but when the animal experimented upon was under ether the difference was much less marked. This would point to the influence of the powerful muscular contractions in the production of lethal effects; as, under the influence of anesthesia, there would be a condition of general muscular relaxation which would tend to minimize this action. D'Arsonval believed that greater danger lay in accidental contact with a high-pressure, continuous E.M.F., because of the electrolytic phenomena which accompany the action of the current. The living body, in reality, is not a homogeneous conductor, and the polar action is produced not only at the points of entrance and departure of the current, but at the surface of each different tissue crossed by the current.

From the physiological action of high-frequency alternating currents of high potential administered therapeutically, as well as from the experiments of D'Arsonval,[4] Elihu Thomson[5] and Tesla[6] with currents of from 100,000 to 200,000 volts, with a frequency of 10,000 periods per second, it would be expected that fatal effects would occur in inverse ratio to the frequency—*i.e.* that a low frequency, or periodicity, is more fatal to life than a high. The higher the frequency the greater the current which can be delivered to the tissues of the body without injury.

It is of interest here to note that alternating currents of high frequency, applied to the exposed heart, produce an increase in the number of beats, and fibrillation does not occur; and that oscillatory currents of high potential very materially hasten the restoration of the coordinated heart beat in dogs in conjunction with the perfusion of the coronary vessels with defibrinated blood. (Cunningham.)

The evidence clearly shows that high-pressure currents are not alone fatal—not even necessarily fatal; that low pressures—95 or 96 volts, and 115 volts, alternating current—are sufficient to cause death; and that while ordinarily pressures under 200 volts are not to be regarded as dangerous to life, and those

over 500 volts as certainly dangerous, everything depends upon the conditions of the conducting circuit. In electrocution, in the present state of experimental knowledge, to insure instantaneous and painless death, currents of high pressure are of necessity chosen.

Accidents in the electrical industries are not unduly frequent as compared with the accidents in other industrial fields; not because the pressures employed would not prove fatal under appropriate conditions, but because these conditions are but infrequently fulfilled.

In the electrocution of criminals, high-pressure currents varying from 1,300 to 2,000 volts—periodicity about 130—are commonly used, and an alternating current of 1,700 volts has traversed the tissues of the body (electrocution, Jaylor, 1893) without arresting the respiration even with an application of fifty seconds' duration, and second and third applications of the current were necessary in order to kill the condemned criminal. (This statement must not be construed as an implication that high-pressure currents, as used in electrocution at the present time, do not kill, but is an illustration of the fact that a high-pressure current is not necessarily fatal. Other factors influence the result, as will be pointed out later on.) The case of Jaylor also illustrates the fact—brought out by the experiments of Prévost and Battelli[2]—that when the pressure is high, even when the heart lies on the line which unites the two contacts—*i.e.* within the conducting path—this organ may not be affected, and that the nervous centers, continuing to be fed, are able to resist the action of the current; nor was the current traversing the tissues sufficient, in this case, to produce inhibition of the nerve centers, with definite arrest of the respiration. For the accomplishment of that result it was necessary to make a second and even a third application.

In the case of McElwaine (second electrocution), in which the points of contact were the head and arms —the hands and forearms being immersed in jars of saline solution—the effects were even less pronounced, and a second application, with the contacts applied to the head and calf of the leg, was found necessary in order to kill him. As in the case of Jaylor, the respiration was not affected by the first application. On the other hand, an alternating current of very much lower pressure—as low as ninety-five or ninety-six volts—has proved fatal in man; while several fatalities (four in number) occurred in a German mill within a short space of time from an alternating current of 115 volts pressure. (Battelli.[7])

In a death resulting from contact with an alternating current of from ninety-five to ninety-six volts, all the conditions of the conducting circuit were good. The subject, a workman in a potash and alcohol plant, was instantly killed by an alternating current of from ninety-five to ninety-six volts. (Kolben.[8]) He stood on an iron tank covered with soda lye—an excellent conductor—and his boots were wrapped with rags of twilled linen. Here was the best of contact, for the saturation of the linen rags implied of necessity a similar condition of the leather of his boots, and no doubt conductivity was increased by the presence of nails in his boots, as is common among working men, although it is not so stated. The contact lasted for from four to five minutes, and the man was a drunkard. In this case, while the pressure was low, the resistance, by reason of position, superficies, and nature of the contacts, was reduced to a minimum and the current strength (or number of amperes) must necessarily have been high. In addition, the heart was in the conducting path, the duration of contact was prolonged, and the man was a drunkard. In this instance, then, everything favored a large electric energy, *i.e.* a pressure, while low, fully effective because of low resistance, and resulting in large amperage; while long contact and diminished vital resistance, by reason of intemperate habits, contributed to the fatal result. The ratio of interruption was unquestionably slow, although not given.

While there does not seem to be any direct connection between the lethal effect and the number of joules, there must be some remote effect, for the greater the energy the greater the chance of death. The conditions in the above instance favored the maximum rate of expending energy, the destructive power of which must have been increased, however, by the prolonged contact (300 seconds). The experiments of Prévost and Battelli show that the fatal effects are due to the energy, and that the energy required for killing a given animal increases in proportion to its weight. In a one-pound guinea-pig, 400 joules were necessary to arrest respiration; while in one weighing ten ounces, but 250 joules were necessary.[2]

From experiments upon animals, accidents from industrial currents, and the electrocution of criminals, it is evident that the lethal effect is due to a sudden discharge. If the same amount of energy in joules was passed through the body slowly, the effects might be quite different. For example, 400 joules, the lethal dose for a one-pound guinea-pig, might mean a pressure of twenty volts, a current strength of twenty amperes continued for one second of time, *i.e.* $20 \times 20 \times 1$ volt-ampere seconds = 400 joules; or $20 \times 0.1 \times 200$ volt-ampere seconds = 400 joules. The result would be very different in each instance. In the first, a sudden discharge of great power; in the second a gradual expenditure of energy, lasting for two hundred seconds, and accomplishing the same amount of electric work, but not violent nor disruptive in its action, as in the former instance. They have shown that the effects of a condenser discharge in causing death or injuries to animals is proportionate to the number of joules not to the number of amperes.

This detailed case, as well as experimental work and the electrocutions instanced, show that the pressure necessary under one set of conditions is not required under another, and that a lethal dose does not of necessity require a current of high pressure. Prévost and Battelli found that under good electrical conditions, a dog—contacts head and hind limbs—could be killed with a current of ten volts pressure; while eighty volts were necessary, under the same conditions, when the contacts were made to the head and fore-legs. In the former instance, the heart lay in the conducting path, while in the latter it did not, and was not only reached indirectly—requiring more power—but, by reason of increased resistance, a greater pressure was required to secure the current necessary to the production of a lethal effect.

This experiment illustrates the influence of the position of the contacts, as does also the case of McElwaine (second electrocution), in whom the head and hands formed the points of contact. In this instance the contacts were good—*i.e.* saline solution—and there was a large superficies; but, by reason of their position, they were objectionable for the purpose contemplated, in that the heart was not placed in the conducting path, and consequently death did not result until their position was changed.

It is clearly shown, therefore, by an analysis of the work of different experimenters as well as of the accidents from industrial currents, that lethal effects follow contact with pressures of widely varying E.M.F.

An accidental contact with a high-pressure line or terminal—or with any pressure for that matter—rarely involves the same set of conditions, and often the conditions existing are such as to render it ineffective as a high-pressure current. Favorable conditions are obtained only (1) in experimental work, and (2) in electrocutions. It is not then a matter of pressure alone, for death results from currents of low pressure as well as from those of high pressure, and the latter are oftentimes ineffective, while a fatal result may follow contact with a low-pressure current.

The matter of vital resistance is of great importance

and must be counted as one of the conditions governing the action of a lethal dose. Kratter,[9] in his experiments, found that a short exposure to an alternating current of 1,500 volts did not always prove fatal to rabbits and guinea-pigs, while others succumbed. With all the conditions of the conducting circuit absolutely the same, and with the animals of the same species, age, and weight, this would indicate to the writer a difference in vital resistance—a factor which cannot be lost sight of in the administration of a lethal dose of electricity any more than in its therapeutic administration.

Cunningham, in his experiments, established the fact that anything acting to depress the vital forces increases susceptibility to the current. For example, after the cervical cord in an anesthetized dog had been exposed and divided, it was found that a very brief passage of a current of 0.25 ampere caused the heart to stop immediately, although previously one of 0.65 ampere had been readily withstood. Whatever serves to depress the general condition increases the susceptibility even to weak currents.

From the action of a low-pressure current, when the effect is upon the heart (*i.e.* causes fibrillar contraction), it is seen that such animal species as rats, frogs, and turtles recover spontaneously, whereas in the higher order of mammals, as well as man, death is absolute; but that from currents of a higher pressure death results in the former with a lower pressure and shorter contact than in the latter. This is when currents of high pressure act by reason of position and nature of contact as such.

The spontaneous recovery of such animals as rats, frogs, and turtles depends upon the phenomena connected with the heart. The action of a low-pressure current is more severe and more lasting as the animal kingdom is ascended. The cold-blooded animals recover from the action of the current on the heart while the warmer-blooded animals succumb. The heart is paralyzed in ventricular tremulations in all animals, and the phenomenon produced varies in intensity according to the genus of the animal. Prévost and Battelli used four genera of warm-blooded animals:

(1) Dogs, in which the characteristic action in the heart (ventricular tremulations) is well defined.

(2) Guinea-pigs—adults—in which the tremulations were most often, but not always well defined.

(3) Rabbits, in which the tremulations are oftenest transitory, but in some cases well defined.

(4) Rats, in which the tremulations last only during the electrization of the heart. When this ceases the tremulations disappear and the ventricles resume their beat. (Battelli.)

These observations are in accord with the well-known physiological fact that while the hearts of the higher mammals very rarely recover spontaneously from a condition of fibrillar contraction, the hearts of those lower in the animal kingdom and of cold-blooded animals do; that in them a lethal effect must be produced by asphyxia, and necessitates the use of a current of higher pressure.

Cause of Death by Electricity.—As a result of the experiments upon animals, of a study of accidents from industrial currents and from atmospheric electricity, and also of electrocutions, the generalization is obvious that death due to an expenditure of electrical energy within the tissues occurs in one of two ways: (1) By mechanical lesions of vital structures, or (2) by arrest of organic functions essential to life—*i.e.* by arrest of respiration, heart's action, or nutritive exchange.

Death occurs, as a rule, in the first way, from lightning stroke, and there is an actual mechanical disintegration of vital structures. This is, however, not always the case. The deaths from lightning in this country are happily very few, being estimated at only about one per million of the population per annum. Oftentimes no trace of injury can be seen upon the subject of the accident, but in other cases various marks are found upon the body, or the clothing will be torn or scorched; and it not infrequently happens that the boots are torn off the feet, and nails driven out of the soles of the boots. The following case illustrates, in a striking manner, the disruptive action of this tremendous energy:

The accident occurred in Guilford, England, August 25, 1897, and the inquest revealed that the man was found, one-half hour after a single flash of lightning and a clap of thunder, lying on his face. Around him, within a radius of several yards, were his clothes and boots, which had been torn and scattered about in an extraordinary manner. The lightning appeared to have struck him on the right side of the head, tearing his cap to pieces and burning his hair off. It then passed inside his collar, down the front of his body and both legs into his boots, which were torn to pieces, and then it passed into the ground, making a hole about eighteen inches in circumference and three inches deep. His collar was torn to pieces, the front of his shirt was rent into ribbons, the jacket and undervest were literally torn to shreds, and the knickerbockers he was wearing were stripped from him and scattered on the ground. His stockings and gaiters were similarly torn to pieces, and on the boots the lightning had a remarkable effect. They were burst open, some of the brass eyelet holes were torn out, nails were forced out, and the soles were torn out. The skin had been torn off the chest and the right leg was torn and blackened; blood was issuing from the mouth and right ear.[10]

In view of the fact that the current strength of a particular stroke of lightning has been estimated at at least hundreds if not thousands of amperes, it is not difficult to account for the phenomena described. (Wurtz.[11])

There is no doubt that a lightning stroke acts sometimes as a high-pressure current, *i.e.* it causes an inhibition of the respiratory center and syncope, and it is in such cases that recovery follows either spontaneously or from artificial respiration. That death sometimes occurs in the first way from industrial currents is unquestionable, and the postmortem findings in some of the electrocutions point to an actual mechanical disintegration of the vascular structures; at least, such seems to have been the case in the twenty-fourth electrocution (Hampton) witnessed and reported by A. E. Kennelly and Augustin Goelet.[12] In this case, upon postmortem examination, it was observed that the blood was driven from the peripheral vessels into the organs and tissues of the chest and head and there was actual rupture of the overdistended vessels. Examination of the brain demonstrated the presence of a quantity of dark blood due to rupture of the blood-vessels. It was estimated that at least two quarts escaped from the scalp and cranium in removing the brain. Upon the removal of the dura mater the vessels on the surface were seen to be distended, while in many places there were evidences of rupture. The same condition existed in the interior of the brain and coagulated blood was found at the base of this organ.

As to the actual mechanism of death occurring in the second way, for a long time there was no uniformity of opinion among physiologists.

An analysis of recorded observations, however, points with but three exceptions to a direct action on the heart as the cause of death. But it remained for Prévost and Battelli and Cunningham to show that the current acted on the heart muscle. Their experiments seem to have been conducted simultaneously and without knowledge on the part of either one as to what the other was doing—as is so often the case when scientific investigation of any sort has been carried to a certain definite conclusion—but the pri-

ority of publication belongs to Prévost and Battelli[2] and Cunningham.[1]*

The experiments of Prévost and Battelli are no more conclusive as to the action of a lethal dose, but are more complete in that they deal both with continuous and with alternating currents of varying pressures, thereby establishing very clearly the apparent discrepancies in the action of low- and high-pressure currents. In the production of electric anesthesia and electric sleep, Leduc's experiments[13] are of more recent date and are pertinent here because of a certain amount of experimentation showing that an electric sleep and apparent death will follow a definite application of an interrupted current of a stated periodicity from 90 to 110 per second and low pressure—rarely exceeding thirty-five volts. In the overdose of such a current necessary to produce death the blood pressure suffers a very marked fall and the inspiratory inhibition is decided. Experimentation with the Leduc current in lethal dosage and method of application should be made to determine its place in electrocution. The lesser expenditure of energy is more seemly and humane than the greater if it subserves the same purpose. Overdosage often defeats the purpose for which it is used but, until this experimental work is done, high-pressure currents of known destructive action are indicated.

Prévost and Battelli determined from their observations that the mechanism of death from both continuous and alternating currents was the same, although the action varied in a slight degree.

From their researches they find that death by electric currents takes place in two ways entirely different the one from the other.

(1) By the action of a low-pressure current, death in man is due to the primary paralysis of the heart in *ventricular fibrillation*. This is regarded as the usual cause of death in accidents of the electrical industries, because, as has been pointed out, the conditions of the conducting circuit are such that a high-pressure current acts as a low-pressure current.

(2) A high-pressure current, when the contacts are good and the heart lies upon the line which unites the electrodes—*i.e.* in the conducting path—does not paralyze the heart of man. In this case the respiration has been resumed, as has been noted at the earlier electrocutions in New York State.

When death takes place, under the conditions just mentioned, it is due to an inhibition of the respiratory center. The heart continues to beat with energy and stops only after the asphyxia. It is in these cases that it is sufficient, as a rule, to practise artificial respiration.

The paralysis which occurred in animals the subject of experiment, through the action of a low-pressure current, *i.e.* 120 volts, they found "analogous to that which is directly obtained from exciting the exposed heart with an induced current, *fibrillary tremulations* of the ventricles, while the auricles continued to beat. This is the well-known phenomenon designated by physiologists as *ventricular tremulations* or *fibrillar contraction.*"

The following phenomena were observed by them in their experiments upon dogs, cats, guinea-pigs, rabbits, and rats:

*Alternating Currents.*—"1. Instantaneous paralysis of vagus and of cervical sympathetic with currents of high pressure.

"2. Non-modification of phenomena described above by previous section of vagus nerves.

"3. The repletion of the heart with blood, even in the case of currents of high pressure and short duration, which seems to prove that the vascular tone and vasomotor centers are not paralyzed.

"4. No appreciable elevation of the temperature, if the time of the pasage of the current is not prolonged.

"5. Rapid appearance of cadaveric rigidity in the case of the currents of high voltage.

"6. At autopsy, absence of constant and characteristic microscopic lesions. Notwithstanding, one finds sometimes hyperemia of the meninges, but not intracerebral hemorrhages, if the subject of the experiment has not been subjected to elevation of the temperature.

"7. *Duration* of the contact is important; respiration, *cæteris paribus*, is more affected when contact has been longer. Convulsions and general tetanus will be more pronounced if the contact has been short. The more the voltage is raised, the shorter is the duration of the contact necessary to cause convulsions.

"8. The *points of application* of the electrodes are a matter of great importance. Their differing position can vary the appearance of this or that symptom.

"*Respiration* will be affected more easily and convulsions more easily produced if one of the electrodes is placed upon the head.

"*Heart.*—The voltage necessary to produce the *fibrillary tremor* is less if the heart is in the line between the poles. Inversely, if the heart is not in this line, it can be thrown into *fibrillary tremor* (*tremulations fibrillaires*) upon the application of currents of high pressure, which, in traversing the heart directly, would not have paralyzed it.

"9. When, after currents of high pressure, the heart of the dog or of the guinea-pig is paralyzed consecutively to the arrest of respiration, *massage* of the heart provokes the *tremulations fibrillaires*, which are wanting in a case of simple asphyxia not produced by electrocution."

*Continuous Currents.*—Conclusions reached:

"1. *Respiration* and *sensibility* react the same to the shocks of closure or of opening.

"2. *Convulsions*, on the other hand, are especially provoked by opening of the current.

"3. As to the *heart*, the fibrillary tremor will come on if the circuit be not closed or opened abruptly. It is a fact, analogous to that which was stated with regard to alternating currents, that a violent excitation can make the fibrillary tremor cease.

"4. Examination of the tracings of arterial pressure seems to indicate the absence of a vasomotor excitation, which, on the other hand, is produced by the alternating currents."

The fact that in some of the earlier electrocutions in New York (McElwaine, Jaylor) respiration was not definitely arrested when the body was traversed by a pressure of 1,700 volts alternating current (contacts good, head to leg, continued for several seconds), is in a line with some of the experiments of Prévost and Battelli. For example, a large-sized dog was submitted to the action of an alternating current of 4,800 volts (contacts good, duration several seconds), and yet spontaneous recovery of the respiration took place. On the other hand, in their experiments with a much lower pressure death was absolute. They found in dogs that these currents of medium pressure produced not only paralysis in ventricular tremulations of the heart, but also absolute arrest of the respiration. In such cases instantaneous death would result from the inhibition of the nerve centers, seconded by the failure of the circulation. In the first instance a repetition of the shock is sufficient to produce a definite arrest of the respiration, and while physiologically death cannot be regarded as strictly instantaneous, it is practically so so far as consciousness is concerned.

In view of the unquestioned fact that currents of the same degree of pressure and applied under apparently the same conditions, both in man (electrocutions) and in animals, produce such different results—

*Cunningham's article was completed toward the end of February, 1899, but was held back until March 31, when it passed into the hands of one of the Prize Committees of the College of Physicians and Surgeons, New York, where it remained until published.

lethal in the one case, and non-lethal in the other—we are justified in concluding that there must be differences in vital resistance. It is very evident from all the evidence forthcoming that the human respiratory system offers a very great resistance to an electric shock, and this resistance is by no means the same in all individuals, just as experiment has shown that it is not so in all animals. The fact that the nervous system is of a higher organization in man than in animals is suggested by Prévost and Battelli as a reason why the function of the respiratory center should be abolished in the former with but a slight increase of voltage. This is not substantiated, however, by the results of electrocution. Prévost and Battelli show by their experiments upon animals that, all other things being equal, the higher the pressure the greater certainty of the definite abolishment of the respiratory function, and they place the pressure necessary for the purpose beyond 1,700 volts.

So far as the evidence is at hand from the electrocutions which have taken place in New York—it appears that the expenditure of this tremendous energy varies in its action in different individuals; that while in one a complete inhibition of the respiratory center from a single application results, in another several successive shocks are required completely to abolish its function; and again, in other instances, there seems to be an actual mechanical disruption (twenty-fourth electrocution), as the blood from every peripheral as well as from the larger vessels is forced by the powerful tetanic muscular contractions into the chest and head, with rupture of some of the blood-vessels. It is fair to suppose that nearly all the energy liberated in the body is expended as heat; and, as a matter of fact, there is a considerable rise in the temperature, although the action of this heat does not bring about death. In this connection it is interesting to note that Prévost and Battelli found that there was no intracerebral hemorrhage when the temperature was not raised, which would indicate a definite relation between the amount of energy liberated and the result.

If this energy acted to produce either inhibition of the respiratory center or paralysis of the heart in ventricular tremulation, there might not be an appreciable rise in the temperature; but when it has acted to produce a disruptive effect, as, for example, in some accidents from industrial currents and sometimes in electrocution (*i.e.* with excessive intracerebral hemorrhage and rupture of some of the blood-vessels), the evidence shows that the rise is considerable. D'Arsonval and Brown-Séquard regarded the rise in temperature in part as the result of asphyxia.

Analysis of the accidents from industrial currents would seem to confirm the experiments of Prévost and Battelli in reference to the action of the current on the respiratory center.

To produce inhibition of the respiratory center, a head-to-spine contact is the most favorable, although a head-to-leg contact contributes to the same result. The latter position of contacts also favors action upon the heart primarily, although a chest to spine, or to spine and head, is better. In a series of cases analyzed, high-pressure currents by reason of high resistance acted as low pressure currents. Although the pressure in every one of these instances was high, the inference is reached, from instantaneous death, that they acted by reason of position and nature of contact as low-pressure currents, and that death was due to paralysis of the heart in ventricular fibrillation. Unfortunately there has never been any opportunity of observing this phenomenon in man, and the inference can be drawn only by the action on warm-blooded animals. By reason of the fact that in the industries the contacts are always bad, both as to position and as to nature, the resistance great, and amperage small, the effect produced is that of a low-pressure current. This effect is more grave when the initial pressure is high—less so with a diminution of voltage.

It is not believed by Prévost and Battelli that the paralysis of the heart in man is always permanent, but that it may sometimes be transitory. This conclusion is reached by them as the result of an analysis of some accidents, and from the fact that the current does not affect all animals similarly; that in some—for example, a guinea-pig—the heart rarely resumes its beats, but that in the rabbit it often resumes its rhythm. These are inexplicable facts, and we have no means of knowing that the human heart may not comport itself similarly.

From experimental evidence there is every reason to conclude that besides the influence exerted by the quality, duration, strength, and density of the current (Tatum) through the thorax, some other factor, apparently residing in the heart and probably physiological in nature, also exercises a considerable influence, as evidenced by the greater or lesser readiness with which the cardiac effect is produced (Cunningham).

*Conclusions and General Considerations.*—Prévost and Battelli as a result of their complete experimental work, arrived at the following conclusions:

1. The heart in man comports itself like that of animals; it is paralyzed in ventricular fibrillations by a current of low pressure.

2. The death of man, in the accidents of the electrical industry, cannot be attributed to arrest of respiration considered as an immediate cause.

3. The death of man in these accidents is due to the primary paralysis of the heart in ventricular fibrillations.

4. Currents of high pressure, when the contacts are good and the heart lies upon the line which unites the electrodes, do not paralyze the heart of man; in this case the respiration is resumed, as has been observed upon electrocuted criminals in America.

5. In the electrical industry the contacts are always more or less bad; for this reason the currents of high pressure act like currents of low pressure and lead to paralysis of the heart.

6. The difference in the results (mortal or not) of the grave accidents of the electrical industry can be explained in two ways: we must assume that the duration of the contact has been too short (fractions of a second) and that the heart has not been placed in ventricular tremulations; or we must admit that the paralysis of the heart of man is not always permanent.

From these conclusions it would appear that in employing a current of high pressure, for the purpose of electrocuting a man, we have secured a result quite different from that which we set before ourselves to obtain, viz., to kill the man rapidly.

The study of the ventricular fibrillation of the heart, which hitherto has offered only a theoretic interest, now assumes some practical importance; for it is to the development of these tremulations that are due the mortal accidents in the electrical industry. The physician, in most of these accidents, is quite impotent, for we possess no *practical* means of re-establishing the beats of the paralyzed heart. Artificial respiration, absolutely useless in the case of well-defined paralysis of the heart, can be sometimes of some use if this paralysis is transitory, in facilitating the normal resumption of the respiration. In any case, artificial respiration is actually the only treatment which the physician has at his disposition.

Cunningham in his experiments reached practically the same conclusion, at about the same time as, and independently of, Prévost and Battelli.

The following are the effects noted: Almost simultaneously with the closing of the circuit with an observed pressure of 116 volts and an observed current of 0.4 ampere, the blood pressure rapidly fell to zero, the tracing showing a few heart beats—auricular. At the closure a deep inspiration was produced, then

there was a deep expiration, followed by cessation of respiratory movement in a state of expiration so long as the current continued to pass. On breaking the circuit a deep inspiration followed by an expiration resulted, and after a few moments a few shallow respirations were observed. Artificial respiration was then begun and was continued without avail for twenty minutes.

The occurrence of natural rhythmical respiratory movements after the opening of the circuit demonstrates that the respiratory center in the medulla is not paralyzed nor instantly killed. Further, the tracings show that an almost total and instantaneous extinction of the arterial circulation is produced. By opening the chest previously and observing the behavior of the heart, it is readily demonstrated that this extinction of blood pressure results from a practically instantaneous cessation of the coordinated rhythmical movements of the heart at the instant a current of 0.9 ampere or even less is passed through a dog. Both ventricles immediately stop beating, while the auricles, especially the auricular appendages, beat with extreme rapidity. On stopping the current the auricular appendages generally resume their usual coordinated rhythmical contractions, which may often continue for a considerable number of minutes. Frequently the auricles will begin to beat again coordinately for a few seconds, but the ventricles rarely if ever exhibit the slightest sign of coordinated contraction. Cunningham noted ventricular contraction in only a single instance, and that only after he had introduced a tube into the jugular vein for the purpose of withdrawing venous blood from the greatly distended heart. This points to a direct action upon the ventricular portion of the heart muscle. The only difference observed, when the points of contact are the chest and fore-leg, instead of the head and chest, is the greatly exaggerated respiration shown by the resultant tracings. Upon opening the thorax immediately after the passage of the current through the heart percutaneously, a careful examination of the still quivering ventricles shows that the coordinated beat of the heart is absent, as a whole, while the various minute bundles of muscle fibers alternately contract and relax with considerable vigor in various parts of the ventricles. As the right cavities of the heart become more and more distended by the accumulating venous blood, the asynchronous quivering of the various little bundles of muscle fibers grows less and less until finally every trace of muscular contraction disappears from the greatly distended ventricle. The action of the current, Cunningham concludes, produces upon the heart the well-known phenomenon described by physiologists as *delirium cordis* or *fibrillary contraction*, "supposed to be caused by some change in the muscular fibers themselves," and Hedley[14] asks: Is this a coagulation by the heat, resulting from the tetanic muscular contractions?

Cunningham believes that there is no question of the instantaneous death of the muscle cells of the heart nor of their paralysis, nor of profound molecular changes invisible under the microscope, resulting from the direct disruptive action of the current. This, he says, is readily proved if Porter's method, or any other method for recovering the excised dog's heart from the condition of fibrillary contraction, is employed. By the use of Porter's method (perfusion of the blood-vessels of the heart with warm, defibrinated dog's blood diluted with 0.8 per cent. saline solution) the excised hearts (still manifesting fibrillary contractions) of numerous electrocuted dogs were made to beat coordinately again and to continue their coordinate contractions for nearly an hour, ceasing then only because of the discontinuance of artificial respiration. It was often necessary to plunge the excised hearts into iced saline solutions in order to stop all movements before coordinate beats could be established. These facts demonstrate that the heart muscle is not paralyzed or killed by the current; for if it were paralyzed no movements would have been observed after the passage of the shock; and if the muscle had been killed no recovery could have occurred on restoring the circulation. It is probable that "the effect of the electrical stimulus has been to disturb the balance of the hypothetical intracardiac coordinating mechanism, the nature and location of which physiologists are still endeavoring to elucidate."

Cunningham points out, as did Prévost and Battelli, that it is well known that the action of various kinds of stimuli upon the exposed mammalian heart—for example, mechanical, chemical, electrical,* and also the stimulus of cold—produce the condition known as fibrillary contraction; consequently the effect is physiological in nature and not one that is characteristic alone of the passage of an electric current.

The experiments of Cunningham, as well as those of Prévost and Battelli, are conclusive in showing that death in dogs—and without doubt also in man, in view of the evidence of autopsies—from low-pressure currents (120 volts), or from those of medium pressure (240-600 volts), or even from currents of high pressure (above 600 volts), when the conditions of the circuit are such as to cause a high-pressure to act as a low-pressure current, is due to the excitation of fibrillary contractions from which the heart of the mammalian rarely recovers. The fact that certain animals (frogs and turtles, for example) recover easily from such a condition explains why they are not easily killed by low-pressure currents, and that to cause death, in these animals, the production of asphyxia by the use of high-pressure currents would be necessary.

In determining the action of a strong, continuous current upon the craniocervical portion of the nervous system, Cunningham placed the contacts directly upon the exposed brain and spinal cord, thereby minimizing the resistance and acting directly upon the nerve centers. The passage of a current of 1.1 amperes for one minute directly through the cerebrum, medulla, and upper cord resulted in the usual deep inspiration followed by expiratory standstill, while the current was still flowing. If the current was not kept applied for too long a time, the respiratory movements generally recommenced a few moments after its removal. At first these movements were feeble, but gradually they resumed their normal rhythm, if the electrode had not been pressed with undue force against the brain. Even when the dose was 1.6 amperes, after the current has been on for several seconds, respiratory inhibition was overcome and pronounced respiratory movements began while it was still flowing. As a rule, however, inhibition of the respiratory center during contact was maintained by a current of 1.5 amperes.

The blood pressure behaves differently when the contacts are directly against the brain and spinal cord, from what it does when they are placed simply against the head and chest;—*i.e.* after a slight rise coincident with the general tetanic spasm of the muscles, produced always by the closure of the circuit, the pressure falls slightly; it then rises to a considerable height, often twice or thrice its original height, if the circuit is kept closed for fifty seconds. If the current is broken at this time it may or may not continue to rise for a few moments, but after this it quickly returns to the normal. On the other hand, if the flow of the current is continued for four or five minutes the blood pressure slowly diminishes, the cardiac action becomes progressively more labored and slower, and finally ceases. If artificial respiration is maintained, this enormous rise in the pressure does

* Weber, Ludwig, and Hoffa, for magnetic electric currents; Einbrodt, Mayer, Herbst, and McWilliams, for continuous currents from batteries and small induction coils. All of these authorities are cited by Cunningham in his treatise.

not take place. If the current is discontinued after the lapse of a minute, the inhibited heart action gradually disappears and respiratory movements, at first slow, soon become natural.

The asphyxia from inhibition of the respiratory center appears to be mainly responsible for the increased blood pressure.

These experiments demonstrated the ability of a strong, continuous current passed through the brain and upper part of the cord to kill; but that the mode of death is quite different from that which takes place when the heart lies in the conducting path and is traversed by the current. In the former the lethal effect is plainly the result of asphyxia due to a respiratory inhibition, while in the latter the lethal result, even from moderate currents continued for a short period, is due to the permanent stoppage of the heart's coordinated action, the central nervous system dying from anemia.

Cunningham's experiments, in common with all others in which these points have been observed, show that a greater amperage is necessary to produce death when the current traverses the supreme nerve centers than when it traverses the heart. In his experiments, the relations were 1.1 to 1.6 in the former as against 0.3 to 0.65 ampere in the latter instance. His conclusions are embodied in the following summary:

"1. Industrial electric currents which traverse the whole body transversely or longitudinally in sufficient intensity kill because fibrillar contraction of the heart is produced and not, as has been hitherto surmised, by producing a total paralysis of that organ or killing it outright.

"2. Such currents neither kill the central nervous system outright nor paralyze it instantaneously. Death of the nervous system from such currents is due to the total anemia following a sudden arrest of the circulation.

"3. In rare instances, when an electric current traverses only the cerebrocervical portion of the nervous system in considerable intensity and for a considerable length of time, it may kill by asphyxia consequent to more or less complete inhibition of the respiratory movements, which occurs chiefly during the passage of the current. No existing facts warrant the conclusion that the medullary respiratory center is paralyzed or killed in such conditions.

"4. Industrial currents are practically non-lethal to frogs and turtles, as the condition of fibrillation quickly and spontaneously disappears from their hearts after the current has ceased to pass. Such animals, of course, can be killed by the very prolonged application of a current of moderate intensity, or by one of enormous voltage and large intensity.

"5. Strong electrical currents applied to the surface of the skin affect the heart in the same manner as currents of less strength do when they are applied directly to the exposed heart.

"6. It may be possible for an electric current of enormous intensity and electromotive force to produce instantaneous death either by its disruptive action or by producing an instantaneous heat coagulation of the cellular constituents of the body. Industrial currents do not kill instantly, although as a result of their action death rapidly occurs. The experience of individuals who have recovered from severe electric shock indicates that such a mode of death is not a painful one.

"7. Spontaneous recovery of the dog's heart from fibrillation produced by strong currents is rare. Spontaneous recovery of the dog's heart from fibrillation and restoration of the arrested circulation after the external application of a strong current for two or three seconds appears not to exist.

"8. Artificial recovery of the fibrillating heart of the dog, with restoration of the circulation and recovery of the nervous system, can be accomplished by the method described in this paper, provided the duration of the shock is short and the procedure is begun immediately after the cessation of the current."

Clinical Manifestations in Electric Shock.—As the result of electric shock in both animals and man there are distinguished five stages of effects: Muscular contractions; clonic convulsions; tonic convulsions with momentary stoppage of respiration; general inhibition of respiration and of the nervous system, but without convulsion; and lastly complete stoppage of the heart's action.

When a strong current is brought to bear upon the subject there is a strong tetanic contraction. Sometimes, not always, when the circuit is broken, a deep respiration takes place followed by an expiratory cry. In a series of accidents analyzed it was noted in but one instance.

Cunningham describes the clinical manifestations in a case of electric shock of which he was a witness. An electrician who was on the point of removing a defective brush from the motor of a trolley car was partially beneath the car, with his right hand on the brush, when he inadvertently rested his left hand on a live rail; immediately his muscles became tetanic and he was thrown backward in an instant, thus severing his connections with the live contacts. Syncope occurred in a few moments, and during its continuance the respirations were at first rather rapid, later possibly a little slower and shallower than normal. His pulse was very soft, rapid, and slightly irregular, but soon consciousness returned. He then vomited once and was able to get up by himself, though he complained of feeling extremely weak. The next morning he stated that the prostration had persisted for about two hours and then disappeared, leaving him as well as ever. The pressure of the current in this instance was 500 volts, but, by reason of the position and nature of the contact (hand-to-hand, dry skin), the resistance was so great as to minimize the current so that probably not more than a small fraction of an ampere passed through him. These effects, Cunningham concludes, are produced as follows: As the accidental contact with the live wires, rails, brushes, etc., is made, more or less pronounced general muscular contractions occur. Respiration may be inhibited after a deep inspiration and expiration, but is quickly resumed. From the moment the shock begins there is temporary inhibition of the heart's action accompanied by a fall in the blood pressure. After exposure to a non-lethal current of brief duration, both normal heart beat and blood pressure are soon recovered. Consecutive to diminution of the blood pressure and disturbance of the cerebral circulation, more or less syncope frequently occurs, but this is gradually recovered from and normal circulation is re-established. When a large portion of the current traverses the brain (head and back of neck contact, for example) the underlying sensory-motor centers of the brain may be stimulated to such a degree that in a few moments one or more general convulsions, quite similar in many respects to an epileptic fit, may be produced. If syncope had not been induced previously by the cerebral anemia resulting from the lowering of the blood pressure and disturbed heart action, the onset of a general convulsion in all probability would be accompanied by complete loss of consciousness. Loss of consciousness is not confined to fatal cases, and the longer it continues the less danger there is to life. It rarely persists longer than a few minutes, but may be followed by headache for several days—possibly by vertigo. In an analysis of a series of accidents, loss of consciousness was prolonged in two cases and in one not completely recovered from for twenty-four hours. It is very rare that sensory or motor paralysis appears as the result of an electric shock. There may occur slight sensory disturbance, motor paralysis, or both. Convulsions sometimes

occur and seem to bear a relation to position of the contacts. If the energy is expended upon the supreme centers they are more apt to appear. In one case the man was blind for forty-five minutes, delirious for several hours, and for several hours unable to speak. Dilatation of the pupils is commonly noted.

In most cases no permanent ill effect appears to follow an electric shock. In a case, however, where the writer's services were required as medicolegal expert death took place two weeks after the electric shock. The current, alternating (trolley car charged), contact instantaneous from hand-to-foot.

One man claimed to feel better in general health after than before. This is not an unreasonable statement in view of the physiological action of an electric current in a therapeutic dose.

The following case is illustrative of the development of traumatic neuroses from electric shock in common with other forms of injury: A workman while at work on an electric transformer, standing on a perfectly dry floor, received a shock of 3,000 volts, with 100 interruptions per second. He lost consciousness for twenty or thirty minutes, and then he was able to get up and walk to the carriage. For about two months he was treated for burns which he had received, and recovered sufficiently to resume his work. Soon afterward he developed a neurosis associated with hysteria and neurasthenia. He presented a concentric narrowing of the field of vision, clonus of the patella, irregularity of the pulse, increased reflex action and muscular irritability, vasomotor disturbances and weakness of the extremities. In other words, this was a typical case of traumatic neurosis developing several months after the injury. The patient finally recovered under bromides, massage, and electricity. (Brustein.[15])

Postmortem Findings.—The postmortem findings in death from electricity present fairly uniform conditions:

1. *Rigor mortis* is always quickly established. Tatum found it generally established in the second or third hour, but it occurred in fifty minutes in one instance. It was established in every instance without any relation that could be traced to the strength of the current. It was never absent where it was sought for, and presented nothing noteworthy in its character save promptness of appearance.

2. The extent of *injury to the skin* in electrical injuries and fatalities varies greatly. The points of penetration of the current are always evidenced by burns of greater or less degree. The place of exit is less frequently marked by burning than is that of entrance. The evidences of burning may be very well marked or they may be, on the contrary, very slight; and they are by no means proportional to the gravity of the accident—depending as they do upon the condition of the skin, whether moist or dry, as well as upon the nature and duration of the contacts.

3. As to the *heart*, Tatum found that if the body was opened immediately after a sudden death the heart was always found to be in a lax condition, both ventricles distended with blood, and both auricles pulsating rhythmically. If the examination was delayed a quarter of an hour or more, or if it followed a less rapid death, the left ventricle was sometimes found empty and more or less firmly contracted. The observations of other experimenters point to practically the same condition of the heart—that, namely, which follows death by apnea.

4. *Blood-vessels and Blood.*—The arteries are often contracted to their smallest caliber and the blood is crowded into the very large veins of the trunk and head. There is sometimes rupture of the blood-vessels (as observed in the twenty-fourth electrocution). Tatum found the blood in the arteries bright red if the body was opened at the end of a minute or so after death; but if the examination was delayed for a few minutes the blood was quite black. On free exposure to the air it turned scarlet as promptly as other venous blood and clotted quite normally. There is an absence of hemoglobin from the blood in death due to electricity, as in apnea. Great fluidity of the blood and absence of clots are marked features in death from industrial currents.

5. *Viscera.*—The viscera are frequently found congested and sometimes engorged with blood.

6. *The nervous system* does not present any gross lesions, but modern histochemical methods tend to show a fundamental action on the cell. This is only in accord with the laws governing cellular activity. Corrado noted: A. Changes with cell contour—(1) Noteworthy and various deformities, erosions, jagged outlines, lacerations, and even severe destruction of the cell outline. (2) The contour of the cell becomes hazy and diffuse. (3) In some cases the protoplasm becomes granular on one side. B. Internal cell changes—(1) The cell contents were more homogeneous and showed the beginning of a chromatolysis. (2) Frequent and pronounced vacuolation (possibly artefact). (3) A slight tendency for the chromatic substances to become dispersed in the remainder of the cell body at times in distinct collections which had a special arrangement in certain portions of the cerebral cortex. (4) The nucleus is resistant but may modify its shape, become diminished in size or may entirely disappear.

The chromatic substance takes on an erratic arrangement or may entirely disappear leaving the nucleus colorless. The nuclear membrane may be broken. (5) The nucleolus is the most resistant part of the cell but tends at times to a diminution in size and has a tendency also to an eccentric position being pushed out to the periphery of the nucleus or even of the cell. On the other hand, there may be gross disorganization of the brain, with destruction of the peripheral cortex and intracranial effusion of blood. The latter, with rupture of blood-vessels, was a marked feature in the twenty-fourth electrocution in the State of New York. Slight hemorrhages in the walls of the fourth ventricle and in the meningeal coverings are not rare.

Prévost and Battelli never found intracranial hemorrhage when elevation of the temperature had been avoided, although there was sometimes hyperemia of the meninges. There is record of a case where there was hemorrhage into the common sheath of the carotid and the vagus nerve on both sides of the neck, and there were also symmetrical hemorrhages along the spinal cord.

In a series of five cases, in which the examination was made at times varying from ten hours to three days after the occurrence of the accident, the postmortem findings may be summarized as follows: In every instance there were marked rigor mortis and great cutaneous congestion, with patches of ecchymosis; the heart was uncontracted and empty; the blood was markedly fluid and would not coagulate; there was but little blood in the large blood-vessels; the viscera were engorged with blood. In some instances there were ruptures of small blood-vessels, and burns of greater or lesser severity were found on different parts of the body. In one case, the vessels of the scalp, meninges, and brain were congested and full of liquid blood, and so also were the lateral sinuses. This accident from a 2,000-volt current seems to have affected the brain instantaneously, as the subject fell as in a fit; but the heart and respiration did not stop until five minutes later.

Is Death Instantaneous and Painless?—The conclusions of Houston and Kennelly, whose experiments were undertaken to answer the above question, are as follows:

"1. That the passage of a sufficiently powerful alternating current through the body of an animal is

followed by instantaneous, painless, and absolute death.

"2. That consequently where electrocution is properly carried out there is not even a remote possibility of subsequent resuscitation of the criminal.

"3. That in case of accidental contact, where the current passing is not excessive, it is quite possible that death may be apparent only, and the method of artificial respiration suggested by Dr. D'Arsonval should invariably be followed."

In the analysis which the writer has made of all the data at her command, and in the evidence furnished by experiments upon animals, by accidental contacts of man with industrial currents, or by electrocutions, there is nothing which contradicts the conclusions just stated. There may be a difference of opinion as to what is meant by instantaneous death, although the experiments of these authorities showed immediate and absolute arrest of the cardiac function.

So far as the ego is concerned, death is no doubt instantaneous, but from the physiological point of view this need not necessarily be true. Physiological death is not, judging from the evidence in many instances, established until some time after conscious death. The results of Cunningham's experiments show that all the tissues of the body, the nervous system and the heart included, are not killed instantaneously, and that the respiratory center continues to act more or less perfectly for some moments after the cessation of a lethal current. On the other hand, in the experiments of Houston and Kennelly, the dogs, with the exception of the one in which the current was passed through the head, died instantly —*i.e.* no cardiac movements nor respiratory effort occurred after the application of the current.

From an analysis of nineteen cases the subject of severe but non-lethal shocks, Cunningham concluded that there was ample time before loss of consciousness for the recipient of the shock to become aware that he was or had been in contact with an electric current. Every one of the nineteen individuals experienced some sort of sensation before consciousness was lost—a sensation which was described by them as similar to that produced by catching hold of the electrodes of a small but strong medical induction coil. Usually a sensation of tremendous pressure is felt across the chest. It does not follow, however, that a lethal would be accompanied by as much sensation as a non-lethal shock. Indeed, to the writer's mind, the question of physical pain from electrocution is not only not proved by the evidence, but disproved. "With the nearly instantaneous extinction of the cerebral circulation, such a rapid and complete cessation of the functions of the cerebral cortex occurs that no time remains for sensations other than those of an electric current to be felt before the cerebral perceptive nerve centers have ceased to act." The suffering must be the mental anguish and consequently of the same character as that experienced by the condemned criminal, no matter how death is to be brought about.

When the enormous pressures used in the industries are considered, it does not seem difficult to believe that death may be instantaneous, even from accidental contact. Continuous currents of ten kilovolts are sometimes used in series arc lighting—ordinarily only three kilovolts are used. The ordinary limit, however, in the case of a continuous current is but 600 volts. In the case of alternating currents the pressures are very much greater and go up to forty or even sixty kilovolts in the long-distance transmission of power.

In the writer's opinion, based upon an analysis of experimental work, accidents from industrial currents and electrocutions, as well as upon the experience of those who have suffered from electric shocks of varying severity, there seems to be no good reason for doubting that death from an electric current, so far as consciousness is concerned, is instantaneous and unaccompanied by any pain save the possible cerebral perception of an electric shock.

Spontaneity of Recovery. Many instances of spontaneous recovery after accidental contact with industrial currents of high pressure are a matter of record. In these cases, as has been pointed out, but little—possibly none—of the current has traversed the heart, by reason of the position and the nature of the contacts. Therefore, the coordinate contractions of the heart are not stopped. Or if the current has traversed the heart, it may not, for some reason inherent in the individual, as suggested by Prévost and Battelli, have established well-defined ventricular tremulations; and consequently, in such a case, after the flow of the current has ceased, recovery takes place. Whether the recovery is spontaneous or is influenced by artificial respiration, depends no doubt upon the degree of inhibition of the respiratory center and the consequent asphyxia. If the nervous system has suffered profoundly before the current is stopped, spontaneous recovery is extremely doubtful, just as it is in profound asphyxia from other causes. In some instances, apparent death from lightning is but a condition of suspended animation, and it is, therefore, well always to practise artificial respiration in all cases of lightning stroke. But where the electrical energy has expended itself in producing a disruptive action, or mechanical lesions of vital organs, efforts of resuscitation are useless.

On the other hand, when a strong current has passed through the heart—Cunningham places it at from 1 to 8 amperes—the organ goes at once into a condition of fibrillar contraction. He considers it most improbable that, after the brief passage of such a strong current, spontaneous recovery of the highly organized heart, with complete restoration of the extinguished circulation, would ever take place. As a matter of fact, he concludes, from his experiments upon fibrillating excised dogs' hearts (with artificial perfusion of blood), that such recovery would never take place spontaneously in the brief interval which exists before the vitality of the central nervous system has become so reduced as to be incapable of recovery. After the arterial blood pressure has disappeared, "I have never seen," says Cunningham, "a single instance, in a series of more than thirty experiments on dogs, in which spontaneous recovery of the coordinated contractions of the heart, with restoration of the general circulation, occurred. The simpler the heart the more rapid the recovery; therefore, the spontaneous recovery in frogs after a severe shock."

In electrocutions, Cunningham believes that if the autopsy is deferred for one hour and no signs of recovery are then manifested by the executed criminal, one may rest assured that recovery could not take place either spontaneously or by artificial means. He points out, however, that the excised heart would probably be made to beat again coordinately if it were perfused with blood.

Resuscitation.—As to resuscitation after electric shock, an analysis of the work of the different experimenters instanced in this paper points very clearly to the inefficiency of artificial respiration when there has been a purposed application of a lethal current; and an analysis of the accidents occurring from electric currents points to the same conclusion.

D'Arsonval, in 1887, and later in 1894, voiced the opinion that after an electric shock the individual should be treated by means of artificial respiration, as in the case of the drowned, "since the condition after the shock is one of suspended animation, in which the respiratory function is suspended." Cases are on record where, after two hours of artificial respiration, breathing which had been suspended from electric shock has been restored.

In those cases in which the heart happens not to be in the direct conducting path of the electrical current (as in brain and spinal-cord contacts), and consequently feels the influence of the latter in a diminished degree, it is quite possible that the establishment of artificial respiration may be found useful. In accidents in which there is but a momentary contact with a current of high pressure artificial respiration is always indicated. But when the current has exerted its power mainly upon the heart and the latter has ceased to beat, artificial respiration will do no harm, but we can scarcely expect that it will do any good. Finally, in those cases in which there has been an actual mechanical and disruptive action, death is absolute and artificial respiration valueless.

It has been shown that after a brief application of an electric current to the exposed heart of a dog, a brief period of fibrillation may be followed by the reappearance of a few coordinated heart beats (Herbst and McWilliams). "Should this occur," says Cunningham, "before the general blood pressure has become greatly diminished, it is possible that the disturbed circulation might be restored. Once, however, it has fallen to zero the right heart becomes so overdistended with venous blood, which may coagulate in a few moments, that even though one or more feeble, coordinated beats occur, the overfilled right heart cannot empty itself with sufficient rapidity through the lungs so that the left ventricle can produce enough pressure in the aorta for the necessary blood to be forced through the coronary circulation rapidly enough for the spontaneously restored coordinate contractions to be maintained."

In those cases in which artificial respiration is indicated, inhibition of the respiratory center (Laborde's method), which Laborde called the physiological treatment of death (*i.e.* rhythmic traction of the tongue), should be practised.

When the action of the electrical current has been upon the heart, the indication is to restore the circulation—not only of the nervous system, but also of the heart—as quickly as possible, in order that the latter may soon recover its coordinated contractions. There is but one way in which this may possibly be accomplished, viz., by the establishment of a temporary circulation of a fluid which will feed the heart and nervous system until the former has sufficiently recovered to perform its function.

The observation of the fact that the employment of oscillatory currents of high potential favors the recovery of a fibrillating dog's heart, and of the results obtained by the use of such currents in therapeutic work, suggests the possibility that a similarly favorable effect may be produced in the human being in cases in which the heart has not been too profoundly affected. Experimental work in this direction could not fail to be of value, no matter what might be the conclusion reached. Further experimental researches into the mechanism of death are also desirable. However, if we are to obtain further knowledge as to when an attempt at resuscitation is likely to prove successful, we must not only extend our experimental researches, but we must also observe with greater care and with more scientific accuracy the phenomena resulting from accidental contact with industrial currents, and we must study more closely the post-mortem conditions. It is also desirable that accurate observations and records should be made of all the conditions of the conducting circuit, of the character and pressure of the current, of the current strength or amperes, of the position and nature of the contacts, and also of the duration of the contact. Such accumulated evidence should be of value in establishing the fact of death and determining its mechanism, or in indicating, in cases of apparent death, the phenomena which warrant the hope that efforts at resuscitation will prove successful.

MARGARET ABIGAIL CLEAVES.

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**Electrocardiograph.**—See *Cardiography*.

**Electrocoagulation.**—(See also *Diathermy*.) Electrocoagulation is a term employed by Doyen, of Paris, to designate a method in which currents of high frequency are used for destroying superficial and accessible neoplasms by coagulation.

Nagelschmidt uses the name *Diathermy* (*q.v.*) to indicate the same process, and also applies it to a method in which an elevation of temperature is produced in the tissues without any destructive results.

Doyen conducted a series of experiments to determine the thermal death-point of various cells, and as a result, advanced the opinion that cancer cells are much less resistant to heat than are the normal cells. By employing very sensitive thermometers, and after a number of corroborative tests, he reached the conclusion that cancer cells are destroyed by a temperature of between 50° and 55° C. (122°–131° F.) while normal cells are resistant up to 60° C. (140° F.).

This claim, in the opinion of Doyen, having been established, an endeavor was made by him to find that form of heat that would meet the necessary requirement of being able to penetrate the deep tissue and destroy the cancer cells lying therein. Hot air, superheated steam, and hot water were employed, but while these agents acted upon the superficial tissue, there was no effect beyond a depth of four to five millimeters, and, consequently, the use of them was abandoned.

About this time, 1907, Pozzi announced to the Paris Acadamy of Medicine the use of sparks of high frequency in the treatment of superficial cancer, whereupon Doyen began the employment of this form of electrical current.

He began to study the action and effect upon cancer in deep tissues, and finally claimed that the heat produced by currents of sufficient strength causes a coagulation of the tissue and a destruction of cancer

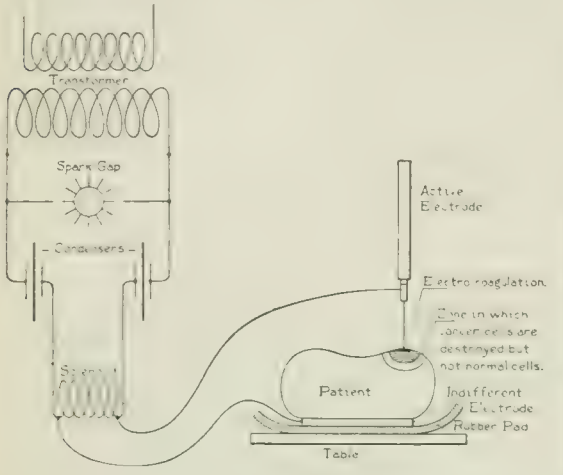


Fig. 1977.—Electrocoagulation. (Modified from Doyen.)

cells, even at a considerable depth, without a destruction of the normal cells at the same depth.

The active electrode may be placed directly in contact with the tissue, thereby suppressing all sparks, designated by Doyen as *electrocoagulation* (Fig. 1977), or it may be held a distance from the part, thus allowing a shower of very short sparks to play upon the area under the electrode. This method is termed *bipolar voltaization* by Doyen.

The tetanic contraction of the muscles was so violent, especially when the sparks were employed, that it was necessary to have constructed an apparatus that would produce a current of higher frequency than that usually employed.

A short description follows of the apparatus used by Doyen, and the similar one imported for test by the Research Committee of the New York Skin and Cancer Hospital. It consists of a portable stand which contains rheostats, ammeter, fuses, switches, etc., from which lead the wires—one pair to a small motor and the other pair, which conducts the alternating current, to a large transformer. A table supports a Ferrié sparking device, composed of a large-toothed wheel made to revolve very rapidly between two fixed copper plates connected to the source of high frequency and to a d'Arsonval condenser. The sparks pass between the copper plates and the revolving teeth of the wheel. The number of revolutions of the wheel can be regulated from the switch-board, thus increasing or diminishing the number of sparks at will. A solenoid is placed in the circuit, and this, with a milliamperemeter to indicate the amount of current passing through the patient, completes the outfit. Two wires lead from the solenoid, one passing to a large metallic electrode placed upon the abdomen of the patient, who lies insulated in a thick rubber pad, while the second wire passes to the active electrode (Figs. 1978 and 1979).

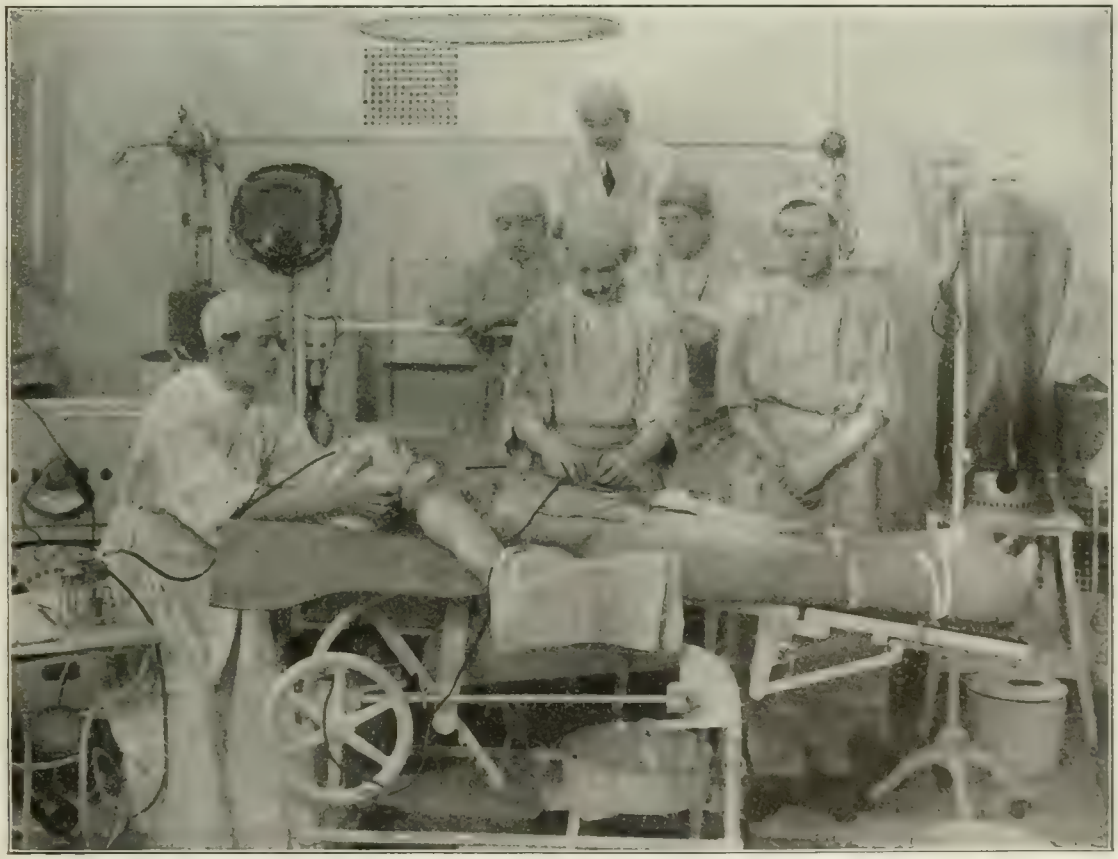

Fig. 1978.—Electrocoagulation of Cancer of the Axilla and Chest Wall. Method of applying the indifferent electrode to the abdominal wall. The patient lies insulated in a thick rubber pad.

The apparatus produces a current of about three million oscillations per second, and of a strength of a maximum of fifteen amperes. Employing an apparatus as described, and with the proper technique, it is possible to coagulate tissue to a depth of five to eight centimeters in from one to two minutes, using a circular electrode three centimeters in diameter.

The active electrodes vary in shape and size, and must be carefully selected for each case. Discs of different diameters are employed upon flat surfaces, as skin and mucous membrane, cylindric forms of different length for use in deep parts, and olive-shaped bodies for treating in cavities, semi-insulated in some instances for use in special situations, as in the rectum, where it is necessary to localize the action without affecting the surrounding healthy tissue (Fig. 1980).

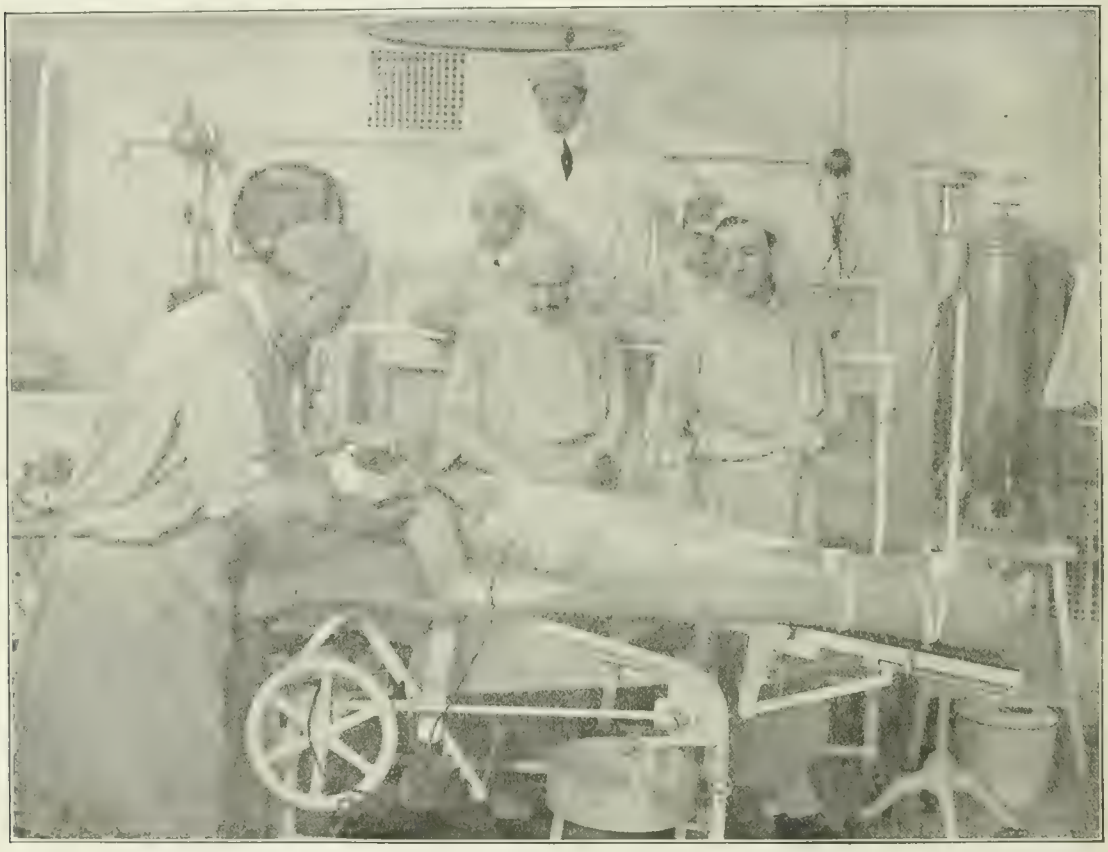

Fig. 1979.—Application of Active Electrode to the Surface of the Cancer. An assistant keeps the indifferent electrode wet during the application of the current.

The effect produced by placing the electrode in contact with the tissue (electrocoagulation) differs very decidedly from that obtained by allowing sparks to pass to the part (bipolar voltaization). In the former case there follows a coagulation of the tissue to a variable depth, depending upon the duration of the application. The temperature within the coagulated zone reaches to from 65° to 70° C. (149°–158° F.), while beyond is an area ten to fifteen millimeters thick, in which there is decreasing temperature from the line of coagulation to the limit of unheated portion of from 65° to 38° C. (149°–100.4° F.). If, on the other hand, the method of bipolar volatilization is employed there is a superficial carbonization in addition to a coagulation in the underlying tissue; this coagulation, however, does not reach the depth produced by electrocoagulation. The temperature is as high as 500° to 600° on the surface of the carbonized area.

Great judgment must be exercised in employing the amount of current proportional to the surface of the electrode. If the current is too strong or the electrode too small for the strength of current, there will follow a very rapid rise of temperature, producing a desiccation of the tissue with carbonization, without coagulation in the deeper parts, while a feeble current or a large electrode will fail to produce any coagulation whatever.

As a rule the method cannot be used unless the patient is deeply anesthetized. Ether is contraindicated because of the danger of an explosion if there should be any sparking, therefore chloroform or one of the other non-inflammable anesthetics must be used.

Electrocoagulation is used to destroy the neoplasms of the skin and of the mucous orifices. The technique with the proper apparatus is simple (Figs. 1978 and 1979). Place the indifferent electrode in contact with the skin of the abdomen after the patient has been placed in the rubber pad. The active electrode is placed in contact with the growth and the current allowed to pass for from twenty to sixty seconds, which usually suffices to cause a coagulation of the mass. During the operation, an assistant keeps the indifferent electrode wet by directing a stream of water upon it. A second application at another time may be necessary if there remains any portion of undestroyed cancer. The slough produced separates in from ten to fifteen days, leaving a granulating surface. Very short sparks may be

employed, but only when the lesion is quite superficial.

In treating cancer that has invaded such cavities as the maxillary sinus, in which the surface is uneven, it is impossible to avoid a certain degree of sparking; but this may be reduced to the minimum by employing the olive or cylindric electrode, which easily passes into the depressions of the part. The same technique is carried out in the treatment of cancer of the buccal wall, tongue, pharynx, larynx, and of the upper portion of the esophagus. The amount of the edema following treatment of neoplasms of the buccal cavity is often very extensive and may necessitate tracheotomy.

Extreme care must be taken while treating in the neighborhood of important vessels, for fear of destroying them, although Doyen claims that the circulating blood keeps the vessels sufficiently cool to prevent the coagulation of their contents, unless the electrode is too near the vessels. The method cannot be employed in treating cancer of the neck in the immediate vicinity of the pneumogastric nerve, for fear of a fatal result, nor can it be employed in cancer of the abdominal viscera. In many of these cases where electrocoagulation might do harm Doyen advises what he calls the *electrothermal bath*, described below.

In cancer of the vagina, neck of the uterus, and rectum, the technique to be followed differs in no particular from that already described except that wooden specula and retractors (Fig. 1980) are employed for dilating the respective canals in place of the usual metallic instruments.

In cases inaccessible to the electrode, as cancer of the bladder, resort is made to surgery in order that the affected part may be directly reached by the current.

There is considerable lymphorrhea following the application of the current, which may last for some days, and which is often of such a degree as to make necessary the use of saline injections and enemata. This fluid is very irritating where it comes in contact with the skin, and if allowed to remain in the wound and be absorbed, will cause systemic disturbance; therefore provision must be made for free drainage. The outflow may serve to flush out the tissue, thus removing cancer-cells, bacteria and their toxins. Very little pain follows; occasionally a secondary hemorrhage may occur, due to the dislodgment of a clot.

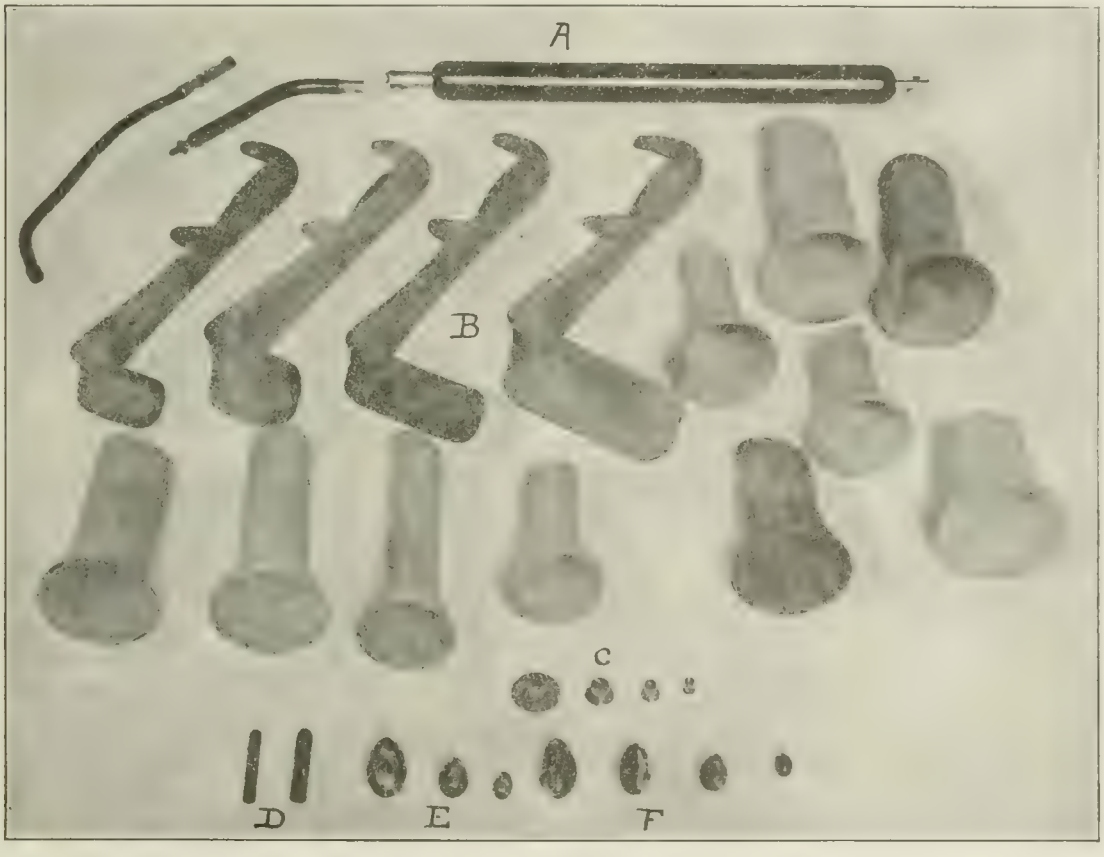


Fig. 1980.—Retractors and Electrodes. *A*, Insulating handle; *B*, wooden specula and retractors used in the vagina, rectum, bladder, etc.; *C*, disc electrodes; *D*, cylinder electrodes; *E*, olive-shaped electrodes; *F*, semi-insulated olive-shaped electrodes.

The success of electrocoagulation depends not only upon correct technique, but upon its employment before there is an involvement of the neighboring glands or viscera.

The advantages, as summed up by Nagelschmidt, are as follows: "Electrocoagulation can be used in those tissues inaccessible to the knife; it destroys bacteria and their toxins; it is hemostatic; it favors elimination of cancer cells in the neighborhood, because of the lymphorrhea; it prevents dissemination of cancer cells during the operation for the lymph, and blood-vessels are coagulated; finally it is not specific, and results depend upon correct technique."

*Electrothermal Bath.*—There are many instances in which the cancer mass is near or surrounds important vessels and nerves and in which electrocoagulation

cannot be used because of danger to these structures. Here Doyen advises the electrothermal bath. After the surgical removal of all visible cancer the cavity is filled with hot saline solution at 50° C. and an electrode placed in the center of the liquid and the current allowed to pass until a thermometer registers 55° to 60° C., depending upon the case. The saline solution is then removed and the wound loosely packed with gauze. According to Doyen, a temperature of 55° C. has no ill effect upon nerves and blood-vessels. In carcinoma of the uterus the patient is placed with the shoulders lowered, the uterine cavity filled with the hot saline solution and raised to a temperature of 60° C.

The reports coming from abroad of the results obtained by these various methods were so encouraging that after a personal investigation by Dr. Bainbridge, the Director of the Cancer Research Department, and the writer, the required apparatus was installed at the New York Skin and Cancer Hospital, and during the past two winters a large number of cases have been treated with the view of determining the value in the treatment of cancer.

It is too early to judge of permanent results but many of the encouraging reports from abroad have been duplicated. The cases that have been treated are being carefully watched and as soon as a sufficient length of time has elapsed to warrant a definite conclusion, a report will be published.

WORTHINGTON SEATON RUSSELL.

**Electrodiagnosis.**—In the use of electricity we have an important adjunct to our diagnostic resources, though it is applicable almost solely in diseases of the nervous system and of the organs of special sense. Discussion of electric apparatus and electrophysiology, as well as of *x*-ray methods and exploration of the body cavities with instruments requiring electric illumination, will be found under the appropriate headings, hence it is necessary here to speak briefly only of the necessary appliances and of the principles involved in the diagnostic use of the electric current. In electrodiagnosis, accurately constructed galvanic and faradic batteries, or better an apparatus in which both currents are generated, are all that are needed, since the static machine and the newer sinusoidal and high-frequency currents furnish us no information from a diagnostic point of view which cannot be equally well obtained by galvanism or faradism.

The galvanic battery should contain a sufficient number of elements to furnish, against the resistance of the human body, a current of from ten to twenty milliamperes and should be provided with an arrangement for throwing in a greater or lesser number of the cells, or better, with a good rheostat, by which the current is regulated by raising or lowering the resistance, the whole number of cells remaining continuously in circuit. It should also have a pole changer and a good galvanometer graduated in milliamperes.

Where the street current is utilized, it is either reduced through the interposition of resistance by lamps, coils of wire, and in the rheostat, or on the other hand it serves to charge a set of storage batteries from which the current is then derived. Where the direct current is available, it can be connected directly with the wall-plate or table-plate, but where the alternating current must be used it is either made to actuate a small dynamo which is so wound as to produce a direct current, or is first passed through one of the so-called "rectifiers," put out by most makers of electric apparatus, in which one phase of the alternations is suppressed, giving a current which is unidirectional but pulsating. Though the current derived from the direct-current dynamo is generally considered to have therapeutic effects, differing little if at all from that produced by chemical means (*i.e.* from cells), it is doubtful if it, much less the "rectified" alternating current, can be relied upon to detect the finer changes in electrical reaction, upon which for diagnosis much depends; so that unless it is possible to use an apparatus in which the street current serves to charge the cells of a storage battery, from which then the galvanic current is derived, it is much safer to depend upon the older chemical battery, at least in cases in which a doubtful condition needs to be cleared up. In the faradic battery, the current strength is regulated by the exposure of a greater or lesser number of the turns of the secondary coil to the inductive influence of the primary coil by drawing out the non-conducting cylinder or damper which is interposed between them, or in some instruments by sliding the secondary coil further and further over the primary.

In standard instruments a graduated scale shows the extent to which the secondary coil is exposed, and the current strength necessary to produce a certain result is expressed in terms of this scale. The figures will vary, however, with condition of the actuating cells, etc., and in general are good only for that special battery. They are chiefly useful in comparing the two sides, the sound and the affected.

With either battery the conducting cords should be long enough for convenience and are best fastened to the electrodes by small screws. These electrodes may have sponge endings, but more cleanly are metal plates which can be covered freshly each time by pads of gauze. The active electrode should be small, the so-called normal electrode being of ten centimeters square surface, though for picking out the individual muscles, one or two even smaller endings are convenient. The indifferent electrode should be large and flat. The electrodes should as a rule be thoroughly wetted, but in some cases of testing faradic sensibility a dry electrode or even the wire brush is used. Salt solution lessens the resistance of the skin but corrodes the electrodes. Plain warm water is generally used, while a little ammonia will soften the skin and decrease resistance to some extent.

The patient should be placed in a good light, with the muscles well relaxed, sitting or lying as is most convenient. With the faradic current, while when using the primary coil, the cathode—or negative pole—is known to produce the strongest contraction, since the direction of the current is constantly changing, we are accustomed to use either pole indifferently. In galvanic examination the polar reactions are of the greatest importance.

The chief and most definite results are obtained in the examination of paralyzed or partially paralyzed muscles. When an electric current is applied, one pole in some indifferent situation and one either to a normal muscle or to the nerve which supplies it, the muscle responds by contracting. With the faradic current, this reaction is of tonic character, relaxing only with the removal of the current or through fatigue of the muscle. With the galvanic current, contraction occurs only at the making or breaking, or when the current is suddenly increased or decreased in strength, and is of clonic character.

In practice the indifferent pole is placed upon the chest or the back of the neck (in the latter situation the patients sometimes complain of disagreeable flashes before the eyes or of a metallic taste, when the current strength is suddenly varied), sometimes, when testing a limb, on the opposite side above or below, while the testing electrode, which can be rendered positive or negative by the pole changer, is placed over the muscle or nerve to be tested. It has been found that there are certain points at which the nerves and muscles are most readily accessible to the current. These points are exposed in the diagrams of the motor points (Figs. 1981–1985), though they vary to some extent in different individuals and must in each case be worked out and when found can be marked with

an aniline pencil. A familiarity with them as well as with the action of each muscle is an indispensable preliminary to successful electrodiagnosis and electrotherapy.

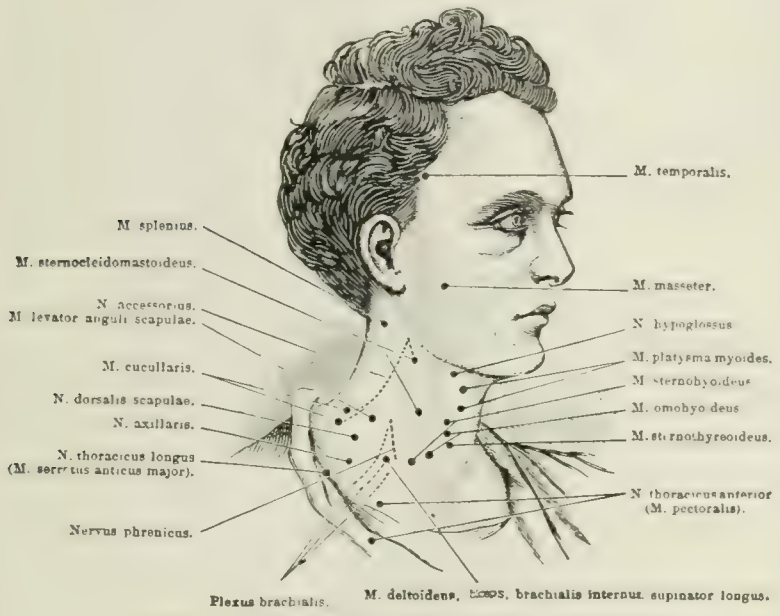


FIG. 1981.—Motor Points of the Head and Neck. (Eulenburg.)

As a matter of convenience faradic examination may well precede galvanic examination, since the higher tension of the faradic current more easily overcomes the resistance of the skin and after this has been thoroughly moistened by the electrodes, it offers less resistance to the galvanic current.

If the galvanic current is applied, the smaller testing electrode over a motor point of nerve or muscle, the large indifferent electrode over a neutral area and the current gradually increased, by turning on the rheostat; with a normal muscle the feeblest current capable of producing any reaction will show itself by a faint contraction when the circuit is closed, the cathode (negative pole) over the motor point—Cathodal Closing Contraction (CaCC). Let the current now be made stronger, and we will notice a stronger CaCC, while there is also a contraction on opening the circuit, the anode on the motor point (AnCC). Still a little stronger, and we get CaCC″, AnCC, and also a contraction on opening with the anode (AnOC). With a very strong current the cathodal closing contraction is tetanic in character, both anodal closing and anodal opening strong, and there is contraction on cathodal opening (CaOC). The normal electrical reactions for the human muscles are hence expressed in the following formulæ.

1. CaCC
2. CaCC″–AnCC
3. CaCC″–AnCC′–AnOC
4. CaCTe–AnCC″–AnOC–CaOC

In character the muscular contraction is quick and sharp, though there is said to be some variation depending upon the size of the muscle, the large muscles of athletes acting somewhat more slowly than those of ordinary people. Quantitatively the reaction is indicated by the smallest number of milliamperes which will produce a contraction.

Stintzing has prepared a table which shows that not only do different nerves vary greatly from one another but there is great variation in the excitability of individual nerves. According to him, the musculo-cutaneous nerve is most irritable, the radial least so. In practice we are generally accustomed to compare the diseased side with the sound side, though where the lesion is bilateral, we have not this advantage and must depend upon the quantitative variation within or outside of the limits given in the tables. The strongest reaction to the galvanic current is obtained by the sudden changing of the poles (voltaic alternative).

Waller long ago showed that when a nerve fiber is separated from its cell of origin by injury or disease, the part peripheral to the lesion undergoes degeneration. When a nerve supplying a certain muscle undergoes degeneration the muscle fibers also degenerate—to the extent that their nerve supply is impaired—lose their tone and power of contracting. A muscle which is undergoing degeneration shows a change in its electrical reactions which when fully developed is quite characteristic. In the earliest stages there may be no loss of irritability, in fact it is sometimes somewhat increased, but within a short time, usually in five days or a week, a change begins. The faradic irritability, when the electrode is applied, either to the nerve or to the muscle, decreases until within two or three weeks it is impossible to make the muscle

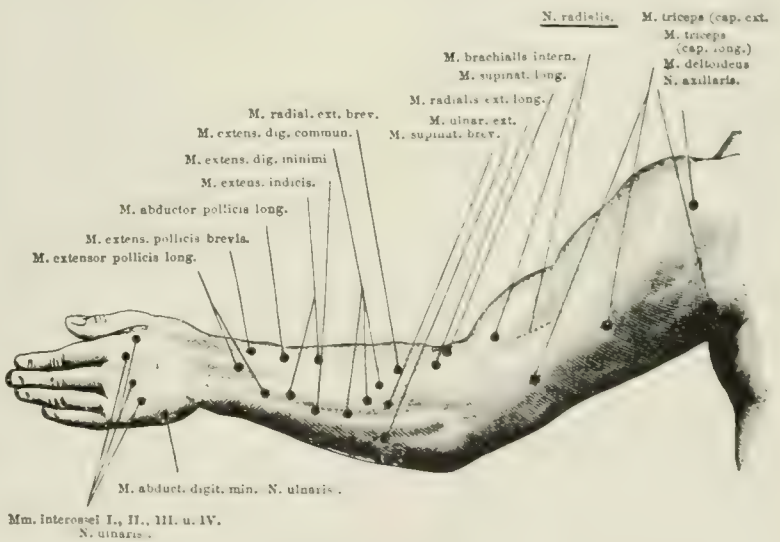


FIG. 1982.—Motor Points of the Upper Extremity. (Eulenburg.)

contract. At the same time galvanic irritability undergoes a change, so that by the time faradic irritability is lost, the galvanic current applied to the nerve gives no response, applied to muscle a contraction is produced and even perhaps with a weaker current than usual but its character has changed and instead of being quick and sharp, it is slow and vermicular, while the polar formula is apt to be altered, the contraction occurring more readily with the anode than with the cathode. This characteristic reaction which has been called by Erb "Reaction of Degeneration" (RD) is always indicative of neuromuscular degeneration and signifies a lesion in the peripheral motor neurone. Gradual change back toward the normal formula with renewed faradic irritability indicates approaching restoration of function. In cases, however, in which no neuromuscular regeneration occurs, faradic irritability is permanently lost, galvanic irritability decreases and is eventually lost, so that finally there is no reponse to either current, by nerve or muscle and the paralysis is permanent. In practice, however, complete RD is much less common than the partial forms, in which faradic irritability is more or less reduced but not entirely lost either in nerve or muscle, while with galvanism there is change in the polar formula and some slowness in contraction of the muscle. This is of much less serious import than true RD, regeneration being usually complete after some weeks or months. Cohn has, however, described a "malignant" form of partial RD in which faradic irritability in both nerve and muscle persists for years, becoming slowly less while galvanic irritability diminishes slowly to normal and below, muscular contraction having a slow character. This condition may remain permanently or in time all contractility may be lost. In RD and its variations we have the most direct and unmistakable diagnostic indications which electric examination is able to furnish, their presence always showing that the cause of paralysis is neither in the muscles, nor in the brain, nor in the spinal cord above the segment from which the affected muscle or muscles receive nerve supply. In practice it always points either to neuritis or to disease of the anterior horn of the spinal cord (poliomyelitis), when in the territory of the cranial nerves to neuritis or nuclear lesion in the bulb.

Quantitative changes in electric irritability in the muscles are, however, more frequent than the qualitative alterations of the contraction which characterize RD complete or partial. They are found not only in the milder cases of neuritis and poliomyelitis, but also in the most varying conditions, as in the slight atrophies following disuse in disease of the brain and spinal cord, in joint affections, and after long-continued pressure upon the muscles by bandages or splints, in the true myopathies (progressive muscular dys-

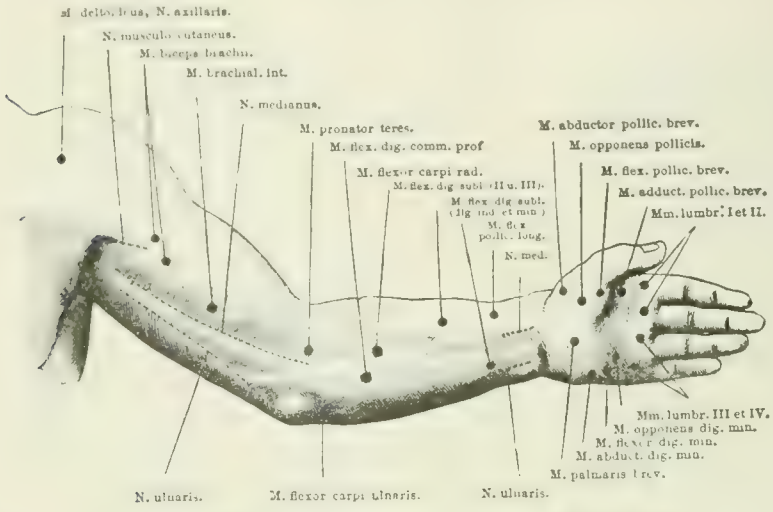


FIG. 1983.—Motor Points of the Upper Extremity. (Eulenburg.)

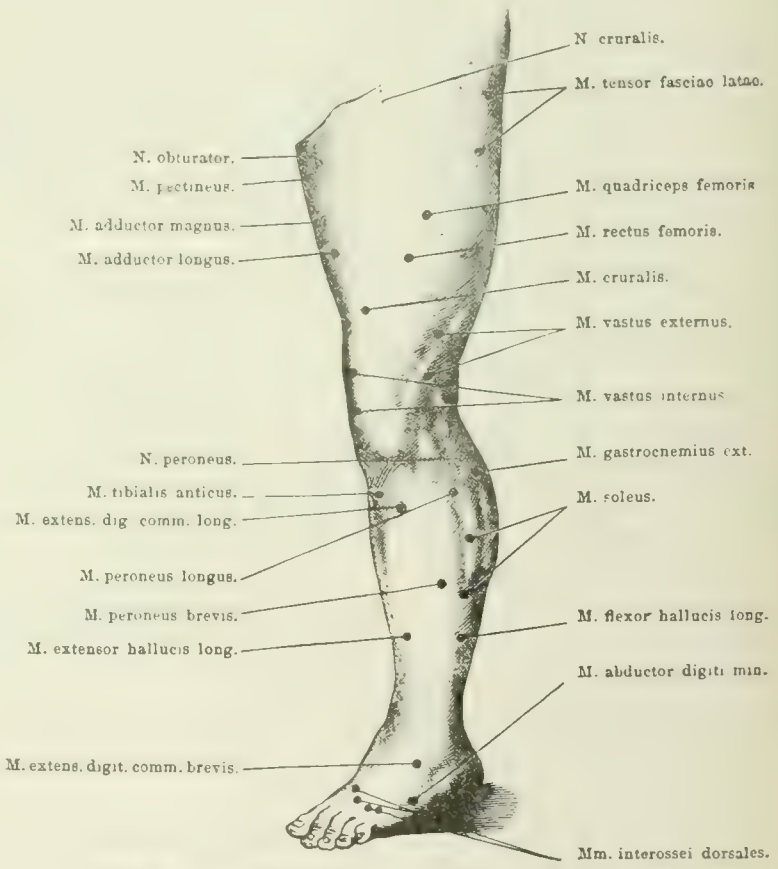


FIG. 1984.—Motor Points of the Lower Extremity. (Eulenburg.)

trophies), being in these last important as differentiating them from the progressive muscular atrophy of spinal origin (now considered synonymous with chronic poliomyelitis), also sometimes in hysterical paralyses, where to reduction of irritability a certain diagnostic importance is ascribed, since it is not found in simulated paralyses. Increase of electrical excitability, when present, is manifested on the contact of either current without change of the polar formulæ. It is found in certain cases of hemiplegia with irritative symptoms, sometimes in brain tumor, in general paresis, occasionally in spinal affections such as locomotor ataxia and myelitis, in the early stages of neuritis, and in progressive muscular atrophy in muscles involved

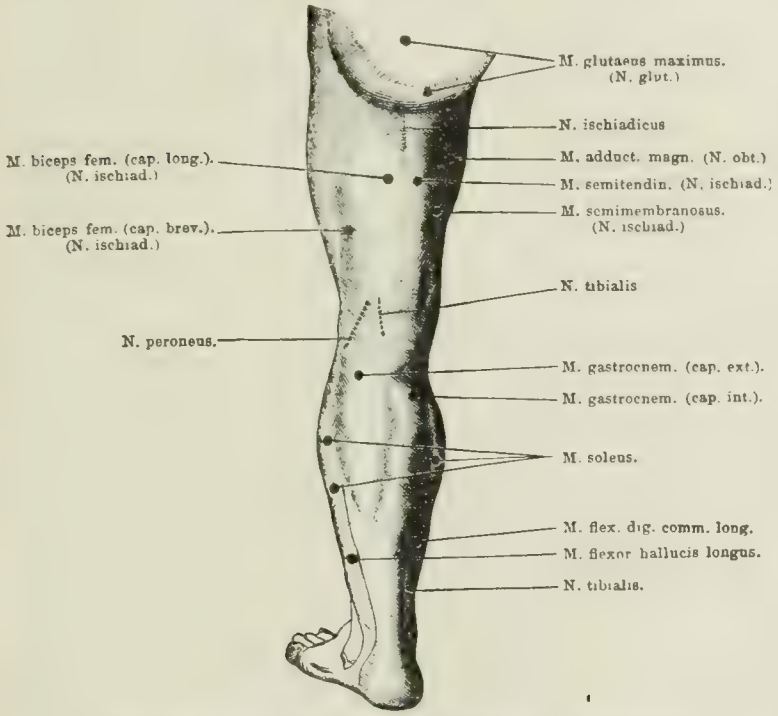


Fig. 1985.—Motor Points of the Lower Extremity. (Eulenburg.)

but not yet paralyzed. Also sometimes in hemichorea and in occupation neuroses, though in none of these cases is its diagnostic importance great, since it is an inconstant manifestation. In tetany increased electrical irritability upon the part of both nerve and muscle is constant enough, however, to he of diagnostic importance. This increase is sometimes so marked that a tetanic contraction can be obtained with the anode.

Other abnormal electric phenomena are the myotonic reaction, the neurotonic reaction, and the myasthenic reaction. In the myotonic reaction, the muscle reacts normally to a weak faradic current. If the current is made stronger the muscular contraction persists in tonic form for some seconds after the current is broken. If the current is passed for some time instead of the usual tonic contraction, the muscle contracts in a wave-like manner. Galvanic muscular irritability is reduced, the polar formula is apt to be changed, the anode producing as strong as or stronger contraction than the cathode and this contraction is prolonged. Strong currents produce a wave-like contraction passing from the cathode to the anode. When faradism is applied directly to the nerve, only a very strong current will tetanize the muscle. To galvanism the nerve is normally irritable or less so.

The myotonic reaction was first described by Erb as characteristic of myotonia congenita (Thomsen's disease), and his findings have since been confirmed by others. The neurotonic reaction consists in persistance of the contraction when either galvanism or faradism is applied to the nerve and is not obtained from direct application to the muscle. Anodal contraction is apt to be increased.

Its diagnostic significance is not clear.

The myasthenic reaction is elicited by application of the faradic current to the muscle direct. The contraction is at first distinct, but gradually shorter and less intense on repeated stimulation, until the muscle is exhausted and refuses to respond. After a period of rest of from a few seconds to half a minute or so its excitability returns, to be rapidly exhausted again upon renewed application of the current. It has been found exclusively in myasthenia gravis (bulbar paralysis without anatomical lesion). In exophthalmic goiter the electrical resistance of the skin is greatly reduced, probably on account of the increased sweat secretion. This is seldom observed until the disease is quite fully developed.

As a means of testing sensation, either general or special, the electric current has not proved of great value. Strong faradic currents are perceived as painful, while with the galvanic a sense of burning is produced. The sensory polar formula in general corresponds with the motor, the cathode being the stimulating, the anode the sedative pole. For testing pain sense, the faradic current may be applied, the indifferent electrode, large and flat, upon the sternum or back of the neck, the testing electrode with a metal terminal—an ordinary wire brush, or best with Erb's special exciting electrode (made of a bundle of 400 fine wires in a hard rubber tube), upon the part to be tested, the strength of the current being determined by the relation of the secondary to the primary coil, as shown by the scale.

Jacoby has described a reaction of some interest. In some cases of tabes he has found that there is faradic analgesia without sensory loss to any other form of stimulation. Why this occurs is unexplained. He also finds that the cathode of the galvanic current passed along the spine will pick out points of special tenderness, so detecting disease of single vertebræ or of special nerve roots.

Application of the galvanic current to the tongue may be used to detect loss of taste, but no more effectively than the simpler methods.

The galvanic current has been used for stimulation of the auditory nerve, one pole being placed upon the tragus of the ear to be tested, the other in an indifferent position. A sense of sound is heard on CaC as soon as the current becomes strong enough, and when it is increased also upon AnO. It is variously described as buzzing, whistling, hissing, or ringing. Under pathological conditions quantitative increase or decrease of the reaction has been observed but no qualitative alteration of the formula. The diagnostic value of this method is not great and if the current is at all too strong it may produce unpleasant sensations of dizziness, nausea and vomiting, pain, and flashes of light.

When the galvanic current is passed through the head, the anode upon one tragus, the cathode upon the other, with two to three milliamperes of current, the patient complains of dizziness and of flashes of light before his eyes. If the current is now reduced to one milliampere the normal person perceives nothing more than a slight light-sensation. Neurotic persons with vestibular hyperesthesia, however, are dizzy at one milliampere or below and often show slight inclination of the head to the side of the anode.

People dizzy from disease of the brain arteries show no increased sensitiveness to the galvanic current (Erben). The galvanic current passed through the optic nerve will cause light-sensations and the olfactory nerve filaments also react with their specific sensation. In neither case, however, have sufficiently characteristic variations from the normal been found under pathological conditions to give to the electric examination a definite diagnostic value.

Within recent years an old observation of Tarchanoff has been taken up particularly by Veraguth Peterson, and others who have attempted to put it to practical diagnostic use. It has been found by these authors that if a person is placed in a circuit in which a delicate mirror galvanometer is included and through which a weak galvanic current is passed, not only any irritation applied to the skin of this individual, but also any question or remark which tends to affect his emotional condition, will produce an alteration in the strength of the current, as evidenced by the movement of the beam from the galvanometer mirror across the magnifying scale with which the apparatus is provided. This has been called by Veraguth the psychogalvanic reflex and he has asserted that it has a value not only in the detection of a hidden emotional complex, but also in picking out, respectively, hyperesthetic and anesthetic areas on the skin. The effect observed has been attributed chiefly to the influence of the emotions upon the vasomotor and secretory apparatus, particularly upon the sweat glands, the resistance of the skin being lowered by their increased secretion. From the delicacy and complexity of the apparatus this method is not likely to come into general use, though in psychophysical examinations it should have some value.

CHARLES LEWIS ALLEN.

**Electrolysis.**—Three essential effects of electricity as applied in therapeutics are (1) the *mechanical*, (2) the *thermic*, and (3) the *electrolytic*.

*The mechanical effects* which, by the induction of successive tissue contraction and release, are capable of producing softening by drainage of infiltrated parts, restoring circulation and metabolism, and effectively overcoming muscular spasm, are most effectively accomplished by the various static methods.

*The thermic effect*, actively producing a heating through (diathermy) of the tissues with the energetic production of hyperemia, accomplishes locally in the parts so heated three valuable effects—(1) increased nutrition, (2) increased metabolism, and (3) an increase in the number of phagocytes thus brought into a field of infection. These effects are most efficiently produced by the direct d'Arsonval method, which may be readily localized and easily regulated, producing the thermic effects without any electrolytic action.

*The electrolytic effect* by which it is possible to produce the local destruction of tissue is produced in different ways: (1) by passing the current into the tissue with an electrode which does not undergo decomposition at either pole, thereby decomposing the tissues by making them the electrolyte; (2) by employing metals or substances which are decomposed and the ions diffused into the tissues (*ionization or phoresis*). These effects are essentially the work of the constant (galvanic) current.

In the consideration of any electrical method or modality the study is best undertaken in contrast with other modalities or methods, particularly so at a time when so many physicians are not informed on the general subject. In treating of the methods under consideration in the limited space allotted, the subject will be considered from the therapeutic point of view leaving the reader to consult works on physics for enlightenment on that part of the subject.

DEFINITION.—Electrolysis is an electrical process in which transformation of substances into their constituent parts is effected by the passage of an electrical current through an electrolyte with the production of ionization of the decomposed particles to and fro with the electrons. The electropositive elements are set free at the positive, and electronegative elements at the negative pole.

*An electrolyte* is a solution or tissue which conducts the electrical current. Pure water, being practically a non-conductor, the presence of an alkaline or organic substance in solution is essential to the passage of the electrical current. Solutions which do not constitute a good electrolyte are: pure water ($H_2O$), glycerin, oils, solutions of sugar, and numerous other substances, which are properly designated non-conductors.

When an electrical current is passing into an electrolyte from the two terminals between the two poles of a constant current, the acid radicals of oxygen basis are collected at the positive pole and the negative radicals with hydrogen at the negative pole. When an electrical current is passing into an electrolyte the acid radicals of oxygen basis are set free around the negative pole, the cathode, and are designated cations, and move in the electrolyte toward the anode, and the metallic radicals (hydrogen) designated as anions, are set free around the positive pole, the anode, and pass toward the cathode.

It will be readily seen under these conditions, that decomposition must take place of a part of the tissue or a part of an organ which is made the electrolyte.

*Ions*, first so-called by Faraday, meaning "travellers," are the particles set free by the division of an electrolyte, or of the substances of the electrodes or solutions with which the electrodes are saturated, into their constituent elements. These are set free immediately from the surface of the electrode by the constant current.

When metal electrodes that are acted upon at the positive pole by the constant current are placed in the tissues, combinations are formed with the saline constituents of the blood with the formation of oxychlorides. Metals that are of practical value for this purpose in therapeutics are copper, zinc, silver, and mercury. The former produces a green stain which renders it objectionable for use on the skin, but is entirely practical for use in the mucous cavities. Iron also is acted upon at the positive pole and produces a black stain, which should always be borne in mind in treating conditions of the skin.

There is a marked difference in the rapidity with which metallic substances are acted upon at the positive pole. Silver is most rapidly diffused and the action is more decisive, and should be employed for shorter periods or with milder currents when used. Zinc is next in activity of dissolution and, though in common use, must be used with care as to dosage. If mercury is employed at the positive pole, it is by means of an amalgamated electrode which is inserted in the tissues. This is accomplished by first placing an electrode in a ten or twenty per cent. solution of sulphuric acid and, while moist, into a vessel of metallic mercury, when a coating of mercury will be formed over the surface of the electrode.

*Ionization*, formerly designated as *phoresis* is a process by which electrical ions convey organic or inorganic substances into the tissues. Such substances are usually deposited in the immediate vicinity

of the electrode, being rarely conveyed to the interpolar tissue. The ionization of organic matter conveys these substances in their natural state into the tissues as demonstrated in the production of local anesthesia with cocaine or blanching of the skin with adrenalin. It is also employed for the transmission of various elements, such as iodine, which can be demonstrated in the urine after an administration of the current by ionization, indicating that the substance maintains its characteristics in integrity.

Apparatus.—The essential apparatus for the scientific employment of the constant current for electrolysis or other purposes is properly a wall plate or table provided with a current controller or rheostat, a milliampere-meter, a volt-meter and volt controller, a pole changer and necessary binding posts for connecting rheophores.

The *current controller* is designed to vary gradually the resistance of the current; starting with full resistance which cuts the current out completely, and by a regulating device gradually allowing the current to pass from zero to the current strength required for the treatment of the condition in hand. A device used for this purpose has a circular face covered with carbon and provided with a metallic dial piece in contact with the face and in the circuit of the current, which by being gradually turned will vary the resistance and thus control the current output. Another current controlling device consists of a wire resistance rheostat by which the current passing is varied gradually from zero to the maximum by systematically varying the resistance, thereby increasing or diminishing the current flowing. A milliampere-meter placed in circuit between the rheostat and the binding post on one side measures the current as it passes through. The meter is provided with a movable indicator and a dial marked numerically in milliamperes—the thousandths of an ampere.

A conveniently constructed milliampere-meter is made to read on two scales by the adjustment of a plug which makes the reading on one scale ten times higher than on the other. By this means it is possible to avoid a very long calibrated index. The milliampere-meter is indispensable for a scientific use of the constant current. Prior to its introduction it was customary to measure the current by varying the number of cells in circuit with a cell selector, which it will be readily seen would, under varying conditions of the electrolyte in the battery and variations in the conditions of the different cells, the weakest cell measuring the strength of the current, occasion an indefinite measure of the current strength, unless great care was taken. The introduction of the milliampere-meter entirely obviated the necessity of a cell selector. Its introduction was an important step forward in the electrotherapeutics of the constant current. The errors previously arising from inexperience brought much discredit upon the use of the constant current and electricity in general; because those who had injured or damaged the tissues of their patients often condemned it thereafter. Their experiences have done much to bring electrotherapeutics into disrepute, and to condemn it in the minds of the rank and file of the profession. There is no current so dangerous in the hands of a novice as the constant current. The milliampere-meter is a safeguard against danger only when the indicated dosage is understood. Careful adherence to all the principles of dosage is imperative.

*The Volt-meter.*—The voltage of the current, that is the pressure or electromotive force (EMF) of the current, indicates its working force, and the *wattage*, which represents all of the elements of the energy expended, is computed by multiplying the milliamperage or amperage of the current by the voltage. In the use of the constant current a voltage rarely of more than 110 is employed and in certain cases, as in the removal of superfluous hair and the treatment of urethral strictures it is desirable that the voltage be much less. The volt-meter and rheostat consists of a device for increasing the resistance in the circuit in a manner that will lower the voltage in conformity with a known law in electrophysics whereby it is shown that the farther the current passes from its source in a direct line conductor, owing to the increased resistance, the more the voltage falls. In this manner resistance placed in the circuit will vary and indicate by means of a specially designed meter the voltage of the current passing. The operator understanding the two factors, current strength and voltage, can by the two meters estimate the exact working power of the current he employs. Only the more recent types of apparatus or wall plates are provided with a volt-meter.

*The Pole Changer.*—It is sometimes desirable in the course of administration of the current, particularly when an active metal electrode connected to the positive pole becomes adherent to the tissue, to change the polarity of the current in order to release it. To accomplish this purpose a device is provided which, by shifting the two points of contact to two adjacent points the polarity of the connecting poles is changed. This device is called a pole changer.

*The Sources of Current.*—Until the institution of the milliampere-meter and proper means of controlling the street current, a series of galvanic cells, dry or wet, were employed as a source of the constant current, and are still a necessity in the office of physicians in country districts not provided with commercial circuits. A series of batteries connecting zinc to carbon alternately, usually employing batteries of about two-ampere and two-volt capacity, arranged in series of sixty cells, will give a voltage of 120 volts, the voltage increasing by the voltage of each added cell. The milliamperage, however, will be measured by the current strength of the weakest cell in the circuit. This law of arrangement is generally well understood; but if further explanation is desired the reader is referred to any good work on physics.

It is still contended by some authorities that the current from a series of galvanic cells is smoother and more uniform than that derived from the direct current of a commercial circuit. However, the majority of observers generally prefer the commercial circuit for practical use where it is possible to obtain it.

*The alternating current* requires some transforming device for rendering it direct, or for deriving a direct current from an alternating-current source. This can be accomplished by means of a *motor dynamo*, which consists of a small motor of the alternating type, connected by means of a continuous shaft with a direct current dynamo; the alternating current being employed as power with which to generate a direct current by means of a small dynamo. This arrangement produces a smooth direct current which is practical and free from any objections. Other devices are on the market employing four moist cells with alkaline solutions into which the current is passed, and which serve as a transformer for converting the alternating current into a fairly uniform direct current. It is a matter of controversy between manufacturers and users of the different methods of transformation as to whether the cell transformer gives as satisfactory a current as that produced by the motor-dynamo. As a matter of fact, either, when properly constructed, proves satisfactory for electrolytic work. The balance of judgment, however, seems to be in favor of the motor-dynamo, which though the first cost is more, requires only oiling to keep it in repair, whereas, the cells of the other apparatus require frequent changing and may be more easily put out of adjustment.

Therapeutics.—The general principles for employment of the constant current for electrolysis demand certain definite rules of operation which must be strictly adhered to, lest with this current in which the

two polar actions are distinctly different, serious mistakes may occur or overdosage be administered to the discredit of the operator and the injury of his patient. It is the rule of all careful operators to test the polarity of the current each time before beginning its administration. This may be readily done by holding the two metal ends of the connecting cords with the current turned on, a short distance apart upon a piece of moistened litmus paper, when, if blue at the positive pole it will be turned red, or if of red litmus at the negative pole it will be changed to blue. The method most in vogue, however, is to hold the two tips of metal in a glass of water, turning on considerable current; at the positive pole there will not be any change whatever, but bubbles of hydrogen will appear at the negative pole.

*Placing the Electrode in Position.*—The indifferent electrode, or the electrode which is not designed to do any particular work in connection with the operation, whether positive or negative, is usually made by placing upon a piece of metal sheeting, usually perforated, a layer of some material of uniform thickness that may be readily moistened, as sponge, punk, absorbent cotton, felt, or other suitable material, which will hold moisture, or a kaolin pad as advised by Dr. G. Betton Massey. Such a pad consists of a thin layer of kaolin of even thickness over which is placed a sheet of metal. This form of pad will always adjust itself smoothly to the surface of the skin, and when administering a large dosage as for the destruction of large cancerous masses by the method of Dr. Massey, is a very desirable form of electrode.

*The active electrode*, or the one which may be employed at either the positive or negative pole according to the indications, should be placed in proper position and then the current turned on, and allowed to flow during the administration. A gentle rotation may be kept up to prevent adhesion to the mucous surface when treating an endometritis with the positive pole or when placed in a sinus. If, however, an electrode of copper amalgamated with mercury is used according to Massey's method it is unnecessary to keep up this manipulation, as a copper electrode so treated will not become adherent.

*Dosage.*—The current strength and duration of an application, as determined by experience, varies according to conditions. In other words, the operator familiar with the employment of the current finds that under definite conditions it is necessary to employ the current for a definite length of time with a definite current strength in order to produce a definite local effect. The current strength and size of the electrode and part under treatment are important factors in determining the dosage, the size of the electrode determining the amount of dosage relative to the current strength, voltage, and amperage. The work done will also vary with the voltage to the extent that twice the voltage of a given current will produce the same effect in one-half the time, or a current of one-half strength in the same time.

*Changing the Polarity.*—If an electrode *in situ* becomes adherent, as to the endometrium or to the wall of a sinus, to remove it forcefully would be a serious mistake. It is, therefore, of great importance that one may be familiar with the method of changing polarity; because a short passage of current from the negative pole will separate it. This, however, does not alter the effect of the work that had previously been done. In other words, the diffusion of the metallic ions into the tissue that has taken place by the positive electrolysis remains, despite the fact that the negative pole is turned on to soften the tissues and release the electrode. To change the polarity, a certain fixed rule must always be observed in the following order of sequence: (1) gradually turn off the current to zero; (2) shift the pole changer, (3) then gradually turn on the current to a strength that can be well tolerated by the patient; (4) gently rotate or manipulate the electrode until it is free; (5) turn off the current gradually and remove the electrode. No electrode should ever be removed during an administration of the constant current for electrolysis or for any other purpose, except for stimulating muscular contraction, without first slowly turning off the current; otherwise an unnecessary shock from suddenly breaking the current circuit will be produced, which is annoying to the patient and may be so easily prevented that there is no excuse for not avoiding it.

*Polarity Effects.*—Strict recognition must be given when employing the constant current in therapeutics to the peculiar actions of the opposite poles upon the tissues. The effects of either pole, when made the active pole, are destructive to tissue, relative to the current strength and the size and character of the electrode employed; because the tissues are made the electrolyte, and hence undergo decomposition, with the added diffusion of metallic or organic bodies, when the active electrode is metal at the positive pole or saturated with an appropriate organic solution.

At the positive pole the oxygen elements accumulate and the tissues become dried and contracted, whereas, at the negative pole, hydrogen collects and the tissues become moist and relaxed. The positive pole has a more energetic and cauterant effect and the oxychlorides of the metals are diffused into the tissues in an even zone beneath or surrounding the electrode, when the metals are employed as the active electrode. Many substances, as cocaine and adrenalin, are also diffused from the positive pole.

At the negative pole the action is less destructive but decided, and from this pole the alkaline salts, iodine, and other bodies may be diffused into the tissues.

The therapeutics of electrolysis may be divided according to the peculiar actions of the opposite poles, respectively into positive and negative electrolysis.

*Positive Electrolysis.*—Diffusion of metals by electrolysis is employed for the destruction of tissues immediately adjacent to or surrounding an active positive electrode by the process previously designated by Dr. Wm. J. Morton as *metallic electrolysis*. To Georges Gautier, a French physician, belongs the credit, however, of having introduced this method of ionization. It is employed in cavities where redundant tissues are to be destroyed, as in the treatment of endometritis, and for the dissolution of sinuses, wherever fistulæ are found, and their closure is indicated, as in anal or rectal fistulæ; for the local stimulation and destruction of neoplastic growths as rodent ulcers, epithelioma, and lupus vulgaris; and for the removal of similar conditions. It is also recommended by some writers for the treatment of varicose ulcers. Radiant light and heat and the static brush discharge, either alone or combined, are, however, more effective and rational means for treating varicose ulcers. Dr. Wm. J. Morton used this method for the treatment of trachoma and other local infections. For trachoma he employed two milliamperes with a U-shaped copper electrode moved about, to prevent adhesion, against the everted lid.

The general technique of employing metallic electrolysis and regulation of dosage depends upon the condition under treatment and size of the electrode employed. In fistulæ when the canal is not too tortuous, and it is possible to pass an amalgamated copper wire into the sinus, the positive pole may be employed with a view to destroying the fistulous tract with a current strength of five to fifteen milliamperes for fifteen to twenty minutes, the energy of the current and time depending upon the size of the electrode and the extent of the condition. One administration will usually effect the destruction of a sinus which will slough away and may promptly close. This result, however, is not always obtained by the first application, and a second application may be required if the destruction of the sinus has not been complete.

In *endometritis* the introduction of an amalgamated

copper electrode about the size of a Simpson's sound, provided with a small vulcanite tip, into the uterine canal, employing a current of twenty to thirty milliamperes for fifteen to twenty minutes, will prove, in most cases, far more effective than a curettage in removing an unhealthy endometrium, which will slough away leaving a healthy surface. If the electrode is well amalgamated it may usually be removed without becoming adherent. If, however, when about to remove the electrode, it is found to be adherent, turn off the current slowly, reverse the poles, turn on the current, and then gently manipulate the electrode until it is separated. After which, turn off the current slowly and remove it. This is probably one of the most valuable methods in electrolysis, and one which might with propriety be generally employed by the profession to the exclusion of curettage in suitable cases.

*The removal of neoplasms* by the method of Dr. G. Betton Massey of Philadelphia is one of the most effective means of destroying these annoying affections. The ionization method advocated by our English confrères is far less effective in these conditions. The method of Dr. Massey effectively destroys the growth and at the same time diffuses the antiseptic oxychlorides into the surrounding tissues.

The technique consists in the insertion of amalgamated zinc electrodes into the growth, including a margin of the healthy tissues in the process. Several needles may be inserted at one time. The current is allowed to pass until the induration is thoroughly softened, when it is turned off and the electrode removed. The destroyed tissues come away in a slough. If treated during the healing process with applications of radiant light and the static brush discharge, they will heal promptly and with a minimum of scarring.

*Carcinoma* is also often treated with success by Dr. Massey's method. In early cases it is possible to remove the growth and so far disinfect the surrounding zone that often there will be no recurrence of the trouble. In order to obtain the best results, it is very desirable that the Roentgen ray should be applied over the area preceding and following this as with other methods. When removing large masses, Dr. Massey has recently introduced a method of placing a metallic indifferent electrode in the center of the tumor and several active destructive electrodes connected with the positive pole surrounding it. By this means destruction is effected by the employment of much less current strength than by the older method. The indication for dosage or continuance of application is based upon the softening of the indurated tissue. As fast as the current is diffused into an indurated mass by this method the latter becomes softened, which the examining finger can easily discern and thereby regulate the effect. This method is invaluable in the treatment of cancer in the mouth including the tongue, the buccal cavities, and the upper pharynx.

In cancer of the tongue it is remarkably successful, numerous cases having remained cured for several years. Dr. Massey has in this manner cured cases which had been previously treated with the Roentgen ray by the writer.

*Tuberculous Adenitis.*—Massey's method of treating tuberculous adenitis is another effective procedure instituted by him. Before the gland breaks down this may be accomplished by making a small incision with a knife, and then inserting an amalgamated zinc electrode, insulated except at the end that passes into the substance of the gland. The oxychlorides of mercury and zinc are thus diffused into the diseased gland with the destructive effects, the gland coming away from the opening in the form of a slough. While this method is successful and produces a minimum of scarring it is questionable if it is applicable to the cases which are effectively cured by the *x*-ray, d'Arsonvalization, and radiant light and heat. In the ulcerated cases, however, in which a curette would be used, the healing process is hastened by the stimulating effects of the current applied to destroy the diseased tissues. In any event, it is preferable to the surgical procedure, as it produces less scarring, and is not so apt to extend the tuberculous process.

*Hemorrhoids* may also be treated by this method, using copper or zinc needles, amalgamated or not, inserted into a large pile. The administration will produce a marked contraction of the pile, and disorganization of the structures which come away as a slough.

The current strength to be employed in most of these procedures will depend upon the number of electrodes, varying from five milliamperes to as high as 400 or 500 milliamperes in the treatment of a large carcinoma. Treatment of hemorrhoids and tuberculous glands and small neoplasms can usually be administered under local anesthesia, and the softening of the indurated tissues will be an index for discontinuing the treatment.

The application of the positive pole to bleeding surfaces will promptly arrest local hemorrhage and is particularly valuable in the treatment of intrauterine hemorrhage occurring with fibroid tumors. For arresting hemorrhage it is customary to use a platinum electrode which is not appreciably acted upon by the current, producing only an electrolytic effect.

*Negative electrolysis* is employed successfully for the destruction of warts, condylomata, moles, and superficial blemishes, also for the removal of scar tissue on the surface and as present in strictures or stenosis of the rectum, urethra, and os uteri. Another purpose for which it is used successfully is for depilation or removal of superfluous hairs, and for overcoming congenital cervical stenosis.

*The removal of warts and moles* is effected by passing a needle which is secured in a proper holder through the base of the wart and gradually turning on the current to the point of toleration of the patient, the positive, the then indifferent pole, being placed upon the arm or in the hand, or wherever it is most convenient. The current is gradually turned on to the point of easy toleration and allowed to flow until the wart becomes white from the accumulation of bubbles of hydrogen when it is turned off and the needle removed. If a wart or mole is large, it may be advisable to make two insertions of the needle. The wart soon turns dark and comes away as a scab, leaving a clean base which promptly heals. This method rarely if ever leaves any scar and is the most practical method of treating those conditions.

*Resolution of keloid or scar tissue* on the surface of the body by the negative pole is a very slow and tedious process, and not so effective as the Roentgen ray. Dupuytren's contraction has been successfully treated by this method of Dr. Herdman of Ann Arbor, Michigan, with surface electrodes.

*Strictures of the rectum and urethra* are also successfully treated by the method of Dr. Robert Newman. It is the method preferred by some operators, while others prefer to use gradual dilatation. Newman's technique consists in observing certain fixed rules with reference to length of application, dosage, and electrodes employed. The negative pole of the constant current is employed in these cases for its divulsant effect with a current strength not to exceed three milliamperes, and a voltage not greater than forty. The electrodes advised are the set manufactured for Dr. Newman by Tiemann. The electrodes are shaped as the urethral sound with vulcanite shaft and a bulbous tip a trifle larger than the size of the shaft. The electrodes are made in the sizes of the French scale. His rule was to employ the current strength mentioned for not more than ten minutes at each seance, and not oftener than every fifth day, the application to be made with very slight pressure, and two sizes (French scale) at each seance larger than at the preceding administration, if the electrode had been passed at the previous sitting; otherwise, to use the

same electrode. The application should never be made when the surface is eroded, nor should a case be treated when an ulceration is present. In other words, an ulcer should always be healed before beginning treatment.

*Depilation.*—For removing superfluous hairs employ the negative pole of the constant current, using a current strength not exceeding one milliampere, employing a very fine needle designed for the purpose held in a suitable needle-holder. The patient should be placed upon a couch or table with the head raised and in a good light. The table or couch should be at convenient height so that the operator may sit and work with convenience. A moistened indifferent pad connected to the positive pole may be so arranged that the patient can place the hand on and off to make and break the circuit as directed by the operator. Each hair to be removed is seized with a pair of small tweezers, and the needle passed along the side and into the bulb of the hair follicle. The patient is then directed to place her hand upon the moist pad. Presently a bubble of hydrogen will rise by the side of the needle. The patient will then remove her hand and the operator remove the needle. If the application has been successful, the hair will be loose and come away without resistance; otherwise, the operation has not been successful. It requires considerable skill and tact to acquire the technique of removing superfluous hairs.

There is no other method so practical as that by depilation in skilled hands, though ten per cent. of the hairs may return, a second or third application will generally remove them permanently. A small current, one-half to one milliampere, insures against scarring. Those who would use the *x*-ray because of its efficiency in removing the hairs, must face the inevitable risk of producing a telangiectasis, because the rays will necessarily be used for two, three, and often four series, successively, before the hairs will cease to return, during which time the skin will suffer irreparable injury.

There are many other conditions that may be treated by electrolysis, but those included are the ones in which the method is most practical. Leduc has advocated ionization in the treatment of boils and carbuncles, but the *x*-ray, the high frequency current, and radiant light are fully as effective if not more so for the cure of these cases.

The diffusion of the salts of lithium and the salicylates into painful areas and inflamed joints by the method of Leduc has been employed, but not often with success. The more modern method of treating these conditions with high potential currents is more practical.

*Local anesthesia* may be effected by the introduction of cocaine by ionization into the tissues, and adrenalin may be diffused for the purpose of producing a local tissue anemia. It is claimed for this method that the effect is more persistent than when introduced hypodermically, because ions are transmitted into the cells instead of being passed on through the lymph channels where they rapidly enter the circulation.

*The introduction of iodine* into the body by the same method from the negative pole, preferably with a solution of iodide of potassium, is considered a valuable procedure by some writers.

Electrolysis is the essential field of the constant current, and the practical purpose for which it is most employed. The high frequency and static currents have, however, largely replaced it in the treatment of inflammatory and painful affections associated with various inflammatory conditions.

William Benham Snow.

**Electrotherapeutics.**—The knowledge of the therapeutic applications of electricity presupposes a thorough familiarity with the main principles of electrical effects upon tissues and organs, and also with the proper dosage of every form of electricity in every given case; it also presupposes a familiarity with the different forms of batteries used for therapeutic purposes. A series of observations shows that the blood-vessels contract and dilate when they are under the influence of an electrical current and that the normal irritability of nerves is changed when a current passes through them. This last phenomenon is called electrotonus. It has been observed that the anode of the galvanic current applied to a nerve diminishes its irritability, while the cathode increases

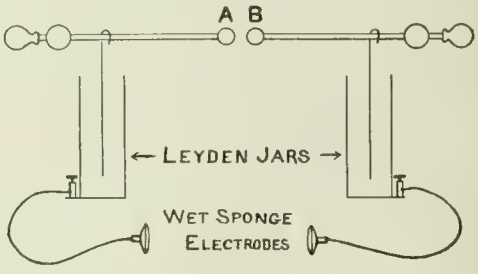


Fig. 1986.

it. The law of electrotonus is equally true of sensory and of motor nerves. Electrical stimulation of a motor nerve produces a contraction of the muscle innervated by the nerve and its branches. A current passing through a sensory nerve will produce pain, while a current influencing a mixed nerve will produce both effects—motor and sensory. Electricity causes muscles not only to contract but also to undergo changes of a trophic character.

Apart from the purely physiological influence upon blood-vessels, nerves, and muscles, electricity shows its chemical effects by means of cataphoresis and electrolysis. By cataphoresis we understand a phenomenon which partakes of the nature of osmosis and which is brought into existence by the action of a galvanic current upon organic tissues. Thus, for example, medicinal substances, as mercury, cocaine, chloroform, etc., can be transferred into the tissues when an electrical current passes through the skin to which the drugs are applied. By electrolysis we understand a splitting up of chemical compounds into their component elements, the acid element being

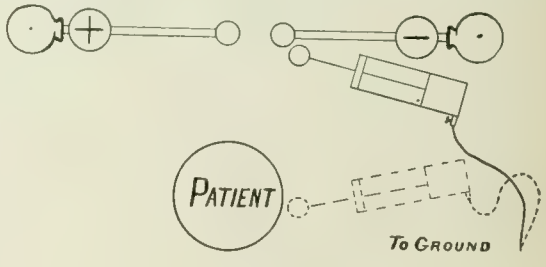


Fig. 1987.

set free at the positive, the alkaline element at the negative pole. In living tissues an acid, dry eschar is formed under the positive pole, an alkaline, moist slough under the negative pole.

Forms of Electricity for Therapeutic Purposes.—The forms of electricity used in therapeutics are: static, galvanic, faradic, high-frequency current, and sinusoidal current.

The application of *Static Electricity* to the body for therapeutic purposes is known as franklinization. This is the form of electricity which is developed by rubbing certain bodies, and which has the property of spreading over the electrical conductors (for example,

metals) and of remaining there. The terminal portions of these bodies have more tension than the middle portions; at the sharp ends the tension is greatest. One distinguishes two sorts of this electricity—positive and negative. By contact with electrical bodies the non-electrical bodies become electrified. Also at a distance the electrical bodies have an influence over the non-electrical bodies (induction). If a non-electrical body is brought into close proximity with the negative pole, the body in question will be found to have assumed the character of a positive pole. For therapeutic purposes one can use direct contact with either the positive or the negative pole. Several methods are employed in franklinization:

(*a*) *Insulation.* The patient is placed upon an insulator and is connected with one pole of the static

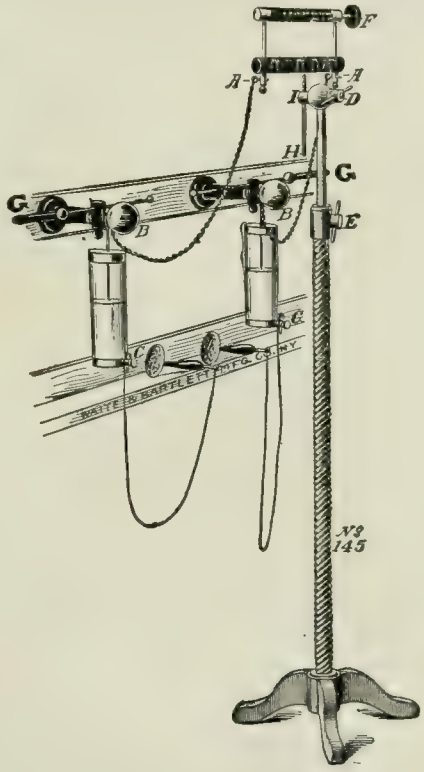


Fig. 1988.—Ranney's Device for Induced Current. To use this device, connect with short chains the poles of the static to binding posts *A A* on device. Use the current through well-moistened sponge-covered discs, the cord tips being connected to the binding posts attached to the Leyden jar supports. Press sponges firmly on part to be treated, and regulate strength by turning *F*.

machine by a chain. The free end of the other pole (also a chain) rests upon the floor. The machine is put in rapid motion. The patient is charged with static electricity.

(*b*) *Sparks.* When a piece of metal attached to the free end of the chain is brought close to the patient's body, insulated as before, sparks will be obtained from it. Sparks are powerful means of exciting deep organs, as well as the skin, and the procedure is attended with pain.

(*c*) *Breeze.* If instead of a ball electrode a pointed electrode is used, a sensation as of a spray will be experienced; this is called a breeze. A good sedative effect is obtained when the electrode is attached to the positive side of the machine and the patient is connected with the negative.

(*d*) *Induced static current.* In this case a pair of sponge electrodes are attached to two Leyden jars, which are suspended from the poles of the machine. Before applying the sponge electrodes to the body, the poles should be approached to each other. An induced static current is thus obtained. One of the best electrodes for this purpose was devised by W. J. Morton, who named it a pistol electrode. Ranney's device (Fig. 1988) is a decided improvement for use in applying induced static electricity. Other electrodes used with static machines are: a

Fig. 1989.—Hydroelectric Bath. (Tousey's Medical Electricity.)

plate for the head, in the form of a crown, and a button-shaped electrode.

*Galvanic currents* are used in therapeutics for general and for local applications. The different methods of employing galvanic currents are termed *central galvanization, local galvanization, general galvanization,* and that by means of the *galvanic bath.* In central galvanization one large negative electrode is placed over the epigastrium and the positive electrode over the head, along the spine, or against the trunk. Each *séance* should last not more than fifteen minutes.

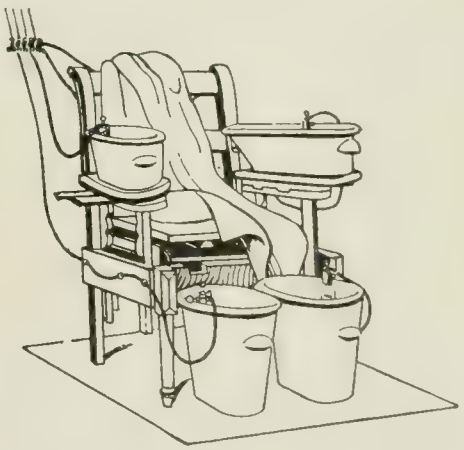

Fig. 1990.—The Four-cell Bath of Dr. Schnee. (Jones.)

In local galvanization the rules of application are the same; the cathode should be placed on some indifferent spot, as the sternum or the neck, and the anode on the diseased spot. In general galvanization the patient is seated on a large negative electrode, well moistened, and the other electrode is applied first to the head, then to the neck, face, upper extremities,

trunk, and lower extremities. As to galvanic baths (*hydroelectric baths*), we distinguish two varieties: *monopolar* and *bipolar*. In monopolar galvanic baths the cathode is connected with the water, while the anode is either connected with a tube lying over the bathtub, which the patient will hold in his hands, or with a large plate which is put on the patient's back or on some indifferent part of the body (sternum, neck). The bath is called cathodal, when the water is connected with the cathode, and vice versa. A bipolar galvanic bath consists of a bathtub, where both electrodes are connected with the water, and the patient is not in contact with either. The currents will pass through the body from one electrode to another. Each *séance* should last at the beginning about ten miautes. As to the strength of the current it may be permitted to reach 100 millampères.

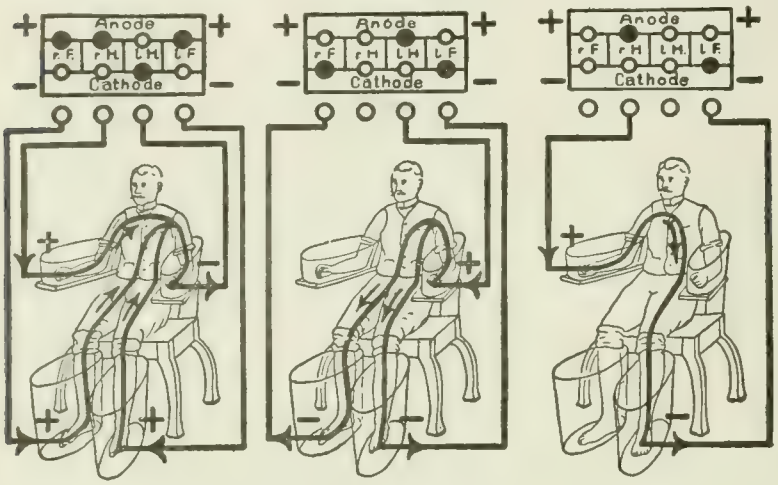


Fig. 1991.—Various Connections of the Four-cell Bath. (Tousey.)

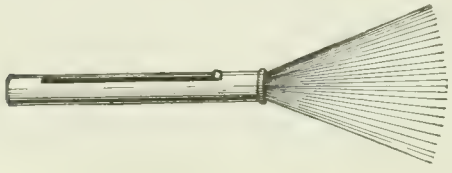

Fig. 1992.—Faradic Brush Electrode.

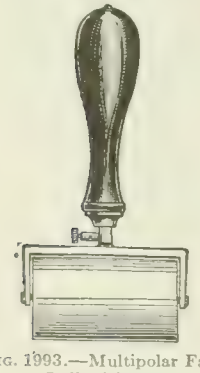

Fig. 1993.—Multipolar Faradic Roller Electrode.

Fig. 1994.—Bipolar Faradic Roller Electrode.

*Faradic Electricity.*—This form of electricity is used in therapeutics both in a general manner and as a local application. The utilization of general faradization is governed by the same rules as those given for general galvanization. The only point to be mentioned is that on account of our inability to measure exactly the strength of the current in a faradic battery we must guide ourselves by the sensory or motor effects. Local faradization which is used for stimulation of the skin, muscles, and deep structures, is obtained by using large sponge electrodes or dry brush electrodes. The method of application is exactly the same as that already mentioned. Special mention should be made of the combination of galvanic and faradic currents in one machine, but we do not as yet possess positive data as to the real value of faradogalvanization.

*High-frequency Current* or *d'Arsonval Current.*—It consists of an induction coil which charges a condenser and a solenoid. The condenser being charged, discharges through the solenoid and a spark gap; oscillations of high frequency are thus obtained. The patient is connected to the opposite sides of the solenoid by electrodes.

*Sinusoidal Current.*—It is an alternating current. A rotatory transformer is brought into action by a direct or an alternating current or else by a battery of accumulators.

Therapeutic Effects of the Various Forms of Electricity.—*Static electricity* increases the blood pressure, accelerates the circulation, stimulates the function of glandular and secretory organs, and restores disturbed functions. It also possesses a sedative influence. Sparks and induced static electricity are indicated when a strong action is sought for such as to promote absorption and regulate the circulation, also to relieve pain. They also have a beneficial effect upon atony of the intestines and pelvic organs. A static breeze is useful in insomnia. A static bath has a sedative effect. The advantage of franklinization is that it can be applied through the clothing.

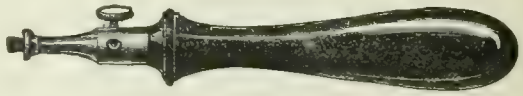

Fig. 1995.—Non-interrupting Handle for Electrodes.

*Faradic currents* have their effect upon muscular contractility and vasomotor phenomena; this form of electricity is therefore indicated in effusions, which will be absorbed through the stimulation of the vascular system. In disorders of deep-seated organs faradism, by producing hyperemia of the skin, will relieve congestion. It influences favorably general nutrition by improving the circulation and all vegetative functions. Besides, in a number of instances it induces sleep.

Fig. 1996.—Interrupting Handle for Electrodes.

*Galvanism* shows its effect in various ways. The vasomotor effect will be manifested in the variation of the caliber of the bloodvessels. As to the trophic effect of galvanism, there is no doubt that atrophies are favorably influenced by this

form of electricity. The chemical effects of galvanism are manifested in cataphoresis and electrolysis (see above). The galvanic current modifies general nutrition and promotes absorption. The latter action was termed by Remak *catalysis*. The chief reason of rapid absorption lies in increased osmotic processes produced by galvanic currents. A special practical application of galvanic currents is furnished in galvano-cauterization. This surgical procedure has an important advantage over other methods of accomplishing the same results. First,

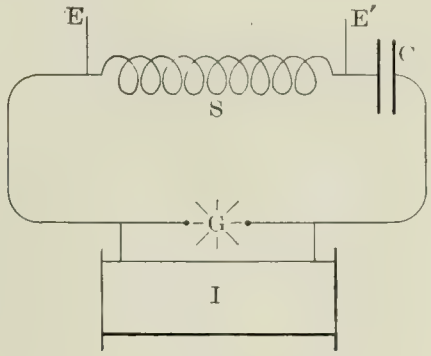


Fig. 1997.

hemorrhage is a rare occurrence, and next, the cauterized surface presents a clean aseptic appearance. In operations in the nose, throat, or other cavities, it has a decided advantage over the thermocautery in the fact that it is applied cold and heated while applied to the diseased spot. This form of electrical application is indicated in ulcers, in angiomata, in fistulæ, where a stimulation of healthy granulations is desirable, in growths which are to be removed from the nose, pharynx, etc.

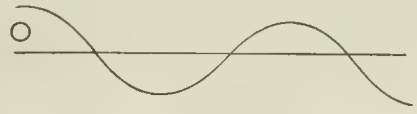

Fig. 1998.

Batteries Used in Electrotherapeutics.—The number of various batteries devised for electrotherapeutic purposes is considerable. They are made stationary and portable. The stationary *galvanic batteries* are the most satisfactory. The cells are put in a closet or cellar and connected with the switchboard by insulated wires. The cells present usually some modification of a Leclanché element. Otto Flemming of Philadelphia, Waite & Bartlett of New

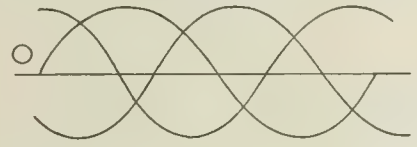

Fig. 1999.

York, and the McIntosh Glavanic and Faradic Battery Company of Chicago make batteries which answer all therapeutic purposes except that of the galvanocautery. They are all supplied with a galvanometer for measuring the strength of the current, an automatic interrupter or rheotome, a rheostat for increasing or decreasing the current, and a commutator for changing the poles of the currents.

G. Betton Massey's movable table for hospital work should also be mentioned. The portable batteries, although supplied with all the accessories just mentioned, lack one desideratum, namely, the steadiness of action of the cells of stationary batteries. The Leclanché cells, or sulphate of copper cells, cannot be used on account of their size and weight, and bichromate cells, or bisulphate of mercury and

Fig. 2000.—Keystone Portable Galvanic Battery.

chloride of silver cells, must take the place of the stationary cells. The writer has tested Flemming's bichromate portable battery, and, although it presents some inconvenience, it is at present the best form of portable battery. The Waite & Bartlett batteries are worthy of commendation. There are now on the market dry chloride of silver batteries which are very convenient.

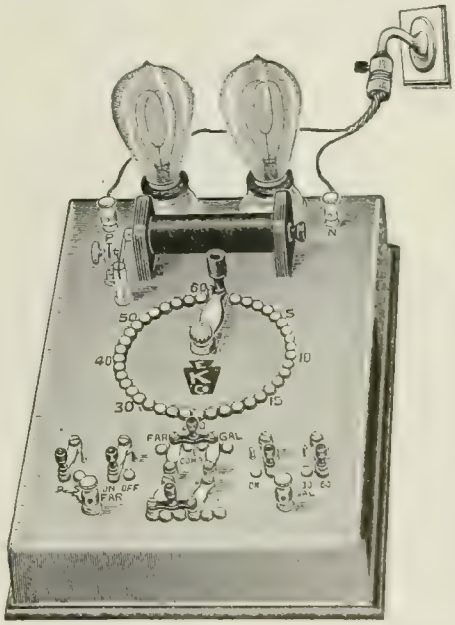

Fig. 2001.—Galvanic, Faradic, and Lamp Controller.

*Faradic batteries* are portable. The DuBois-Reymond coil is taken as a type, and different variations of it have been introduced by different makers. Flemming, for example, has improved DuBois-Reymond's coil in a very advantageous way. Dry chloride of silver batteries in the hands of the writer have proven to be extremely satisfactory.

All the *static machines* devised for electrotherapeutic purposes have for basis Holtz's original machine. The McIntosh Battery Company of Chicago, Waite & Bartlett of New York, Queen & Co. of Philadelphia, make these machines with a high electromotive force. R. V. Wagner & Co., of Chicago, have lately devised a powerful static machine, in which the use of mica plates (instead of glass) constitutes the principal feature. This new arrangement promises a very high speed. A machine constructed with mica plates twenty-eight inches in diameter can be run at a speed of more than 2,000 revolutions per minute, whereas a machine with glass plates of corresponding size cannot be run faster than at a rate of 400 revolutions per minute; and, furthermore, as the generating capacity of the machine is in direct proportion to the speed at which it is run, a machine having two revolving mica plates has a much greater capacity than one having many times this number of glass plates (Fig. 2004).

Fig. 2002.—Faradic Battery with Slow and Rapid Interrupter.

As to a galvanocautery outfit the following requirements are necessary: the elements must be of a large surface, and the battery itself of a small internal resistance; the current must produce a sufficient degree of heat in the cautery ends. While the cautery batteries are stationary, they are, as a rule, portable. Fig. 2005 presents an outfit sufficient for ordinary work. For laryngeal operations Schrötter's laryngeal cautery instruments are very satisfactory (Fig. 2006). For general cauterization purposes

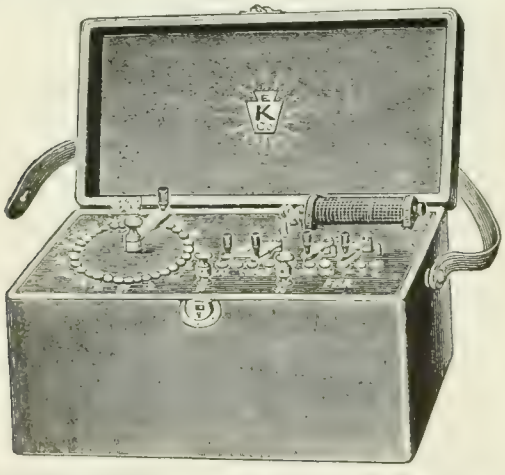

Fig. 2003.—Portable Combined Faradic and Galvanic Battery.

Dawson's cautery battery and Bruns' cautery battery, as made by the McIntosh Co., are to be commended. For high frequency currents one of the best machines is Allen's "Cage Solenoid for Autoconduction." (Fig. 2007.)

Rules for Applying Electrical Treatment. - The rules which the writer has here formulated are general in character, and the therapeutist should adapt them to each individual case, using his own judgment as to the necessity for changing them. Before any application is made it is very important to localize the disease; but sometimes difficulties arise. For example, in palsies of ocular muscles, or

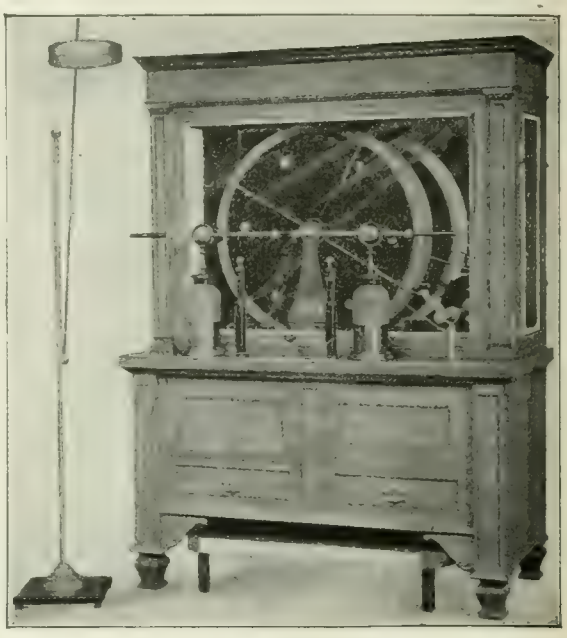

Fig. 2004.—Wagner Static Machine, with Four Revolving Mica Plates (diam. 28 in.) and Four Stationary Glass Plates (diam. 31 in.).

in functional neuroses in which the exact place of the disease is unknown, or, finally, in progressive pathological processes of the central nervous system, in which the direct application of a current is an impossibility, we must content ourselves with symptomatic treatment—*i.e.* we must apply the current to a place where, although it may be remote from the diseased focus, the most pronounced symptoms have been observed.

The next important consideration in electrotherapeutics is *the dosage of currents.* A strong galvanic current produces on the skin, and especially on the mucous membranes, painful, burning sensations, and is apt to injure the integument, so that sometimes after a single application an ulcer forms. The beginning of pain serves as a warning in regard to the strength of the current. Only a slight burning sensation is permissible. Faradic currents of stronger power produce only pain and redness of the skin; nevertheless, one should not use at the beginning a

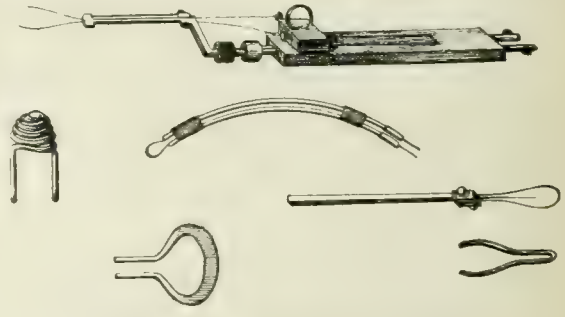

Fig. 2005.—Small Galvanocaustic Operating Set.

strong faradic current, because it is likely to frighten the patient and so to call forth resistance on his part. Galvanic currents of average strength, when applied to the head and neck, cause dizziness, flashes before the eyes, a peculiar taste in the tongue, nausea, tinnitus aurium, and in hysterical patients cramps and spells of all sorts. The same symptoms are sometimes observed even with milder currents when applied to the head and neck. They occur at each closure and opening of the current, especially when the increase or decrease of the strength of the current is produced abruptly, and not gradually. It is therefore necessary in applying electricity to that part of the body to use a rheostat and cautiously to move it forward or backward. The needle of the galvanometer will indicate whether the increase or decrease is rapid or not. The needle should not make abrupt movements, but slow and regular ones in the desired direction. It is advisable to put in as few elements as possible and to use up the whole rheostat or at least a large part of it. By this means it will be easier to avoid sudden changes in the strength of the current than if we employ many elements, as in the latter case the changes are more marked and sudden ones are more difficult to avoid in spite of the rheostat. In the employment of the latter, for either increasing or diminishing the strength of the current, it is strictly necessary to effect the change in a gradual manner, especially when we are making a polar application, *i.e.* when we wish to obtain an anodal or a cathodal result. For example, in neuralgias we use the anode of the galvanic current in order to diminish or allay pain. In this case we must be particularly careful to increase the strength of the current, by means of the rheostat, very gradually. It is equally important not to reverse the current while it is closed, neither must we close or open it suddenly. It is therefore a good plan to instruct the patient not to remove the electrodes before the séance of treatment is terminated. In such cases one electrode should be provided with an interrupter, by means of which the closure and opening of the current can be effected in a gradual manner. For therapeutic purposes the electrodes should be first applied to the desired places, and only afterward should the current be turned on very gradually. In terminating a séance it is well first to remove the current (by a slow turning back of the handle of the rheostat), then to disconnect the elements, and last of all to remove the electrodes.

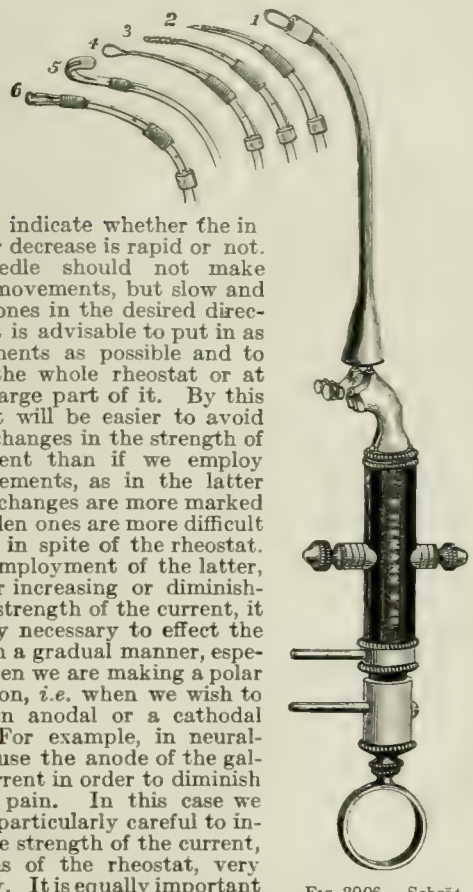

Fig. 2006.—Schrötter's Laryngeal Cautery Instruments.

If direct effects on muscles and nerve trunks are desired, one must moisten the electrodes *thoroughly*, because the resistance of the skin will thereby be diminished. Dry, especially metallic electrodes (brushes, etc.) exert a direct effect on the skin, and only an indirect one (through reflex action) on the central nervous system and the circulatory apparatus. They are especially used for faradic applications. For galvanic currents metallic electrodes are not advisable because of their injurious effect upon the skin. It is desirable, therefore, when galvanic currents are used, that the electrodes should be well covered in order that the patient's skin may not come in contact with their metallic parts.

In recent cases electrical applications should be made daily; in old cases every other day. When the applications are made less frequently they produce a suggestive rather than a therapeutic effect.

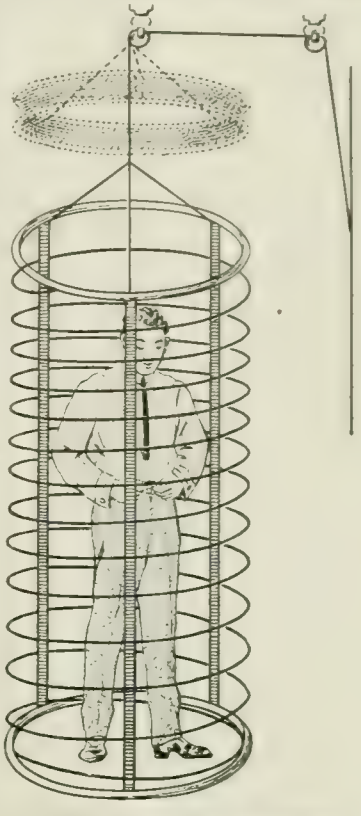
Fig. 2007.—Allen's Cage Solenoid for Autoconduction.

Electrotherapeutic Applications in Diseases.—The question of the real value of electrical applications in various diseases is even at the present time under discussion. Some authorities do not believe at all in the curative effect of electricity. Opposed to this absolutely sceptical view there is another which is held by men who believe in the curative value of this agency, but only through its influence upon the patient's mind. This latter influence, it must be admitted, is sometimes competent to remove or allay certain unpleasant symptoms, especially those of a nervous character, which accompany certain diseases. The third view is that which is held by the majority of writers, viz., that the various electric currents do actually exert a curative effect upon certain pathological conditions of the living body. They base their views on: (*a*) exact clinical experiments; (*b*) experiments on animals, in which the psychic effect is out of the question, and in which artificially produced diseases are cured by means of electrotherapeutic methods; and (*c*) the fact that electrical currents show their effect especially on the nervous system. The study of the clinical data concerning the applications of electricity in diseases of various organs permits us to arrive at the following conclusion: the electrical current produces, in addition to the psychical influence already mentioned, the following well-established effects; a chemical effect upon the fluids and solids of the body, an effect upon the smooth muscle cells of the blood-vessels, a stimulating effect upon the nerves, an effect upon striated muscular tissue (contraction), and finally changes in the molecular life of the tissues in general.

Diseases of Peripheral Nerves.—(*a*) *Neuralgia.* The irritability of the sensory nerves is diminished by the application of the galvanic anode. The application is made in the following way: one electrode of

larger size is thoroughly moistened and applied to some indifferent spot (sternum, back); the smaller electrode is placed on the spot which is considered to be diseased. The number of elements to be used is always determined in advance (on the head and neck they should be fewer than on any other part of the body). With the rheostat we can slowly and gradually regulate the strength of the current, and the galvanometer will show the desired strength. The number of milliampères shown on the galvanometer will depend upon (1) the localization of the nerve (for the fifth nerve the maximum will be 2 ma., for the brachial plexus about 4 ma., for the sciatic nerve about 8 ma.; (2) the length of time during which the disease has existed (in recent cases use weaker currents); (3) upon the sensibility of the individual. Each séance devoted to such an application of the electrical current should not last more than five or six minutes.

Descending galvanic currents are also found to be of value in allaying pain. When we use such a current we should apply both electrodes to the nerve trunk at a certain distance from each other; the anode being placed centrally and the cathode peripherally. Of course this is possible only in cases in which the nerve trunks are not far from the surface. Thus, for example, in cases of sciatica the anode should be placed in the middle of the gluteal fold and the cathode in the popliteal space at the point where the nerve divides into two branches.

In old neuralgias the *voltaic alternative currents* are used. They are produced by abrupt or rapid movements of the rheostat after both electrodes have been placed according to the general rule.

As to the faradic current it can be used with a faradic brush electrode, which should then be the anode and with which a massage should be exercised over the painful area, while the cathode is kept immovable on an indifferent spot. This procedure will often allay pain.

Cataphoresis with various drugs has been practised by many authors, and comparatively good results have been obtained. According to this method the remedy for relieving pain is applied to the anode which is in contact with the neuralgic area. The cathode is placed on an indifferent spot. By employing cataphoresis with cocaine and with aconitine Peterson and Séguin were successful in relieving patients who were suffering from supraorbital neuralgia.

Treatment by high intensities has been recommended in tic douloureux. An electrode attached to the positive pole is placed on the diseased side, while the indifferent electrode is placed on the back. The current is gradually increased to 30–50 ma. and is allowed to remain at this strength for from half an hour to an hour. Direct application of the vacuum electrode of the high-frequency machine to the point of exit of the nerve or over the entire painful area may give very satisfactory results. In sciatic neuralgia autocondensation for about five minutes gives considerable relief (see figure of apparatus above). The patient is sitting on an insulating indurated fiber covering a sheet of metal while his back rests against another. Salicylic ionization has been advised in tic douloureux by Leduc (*Arch. d'Electr. Méd.*, 1905). The cathode is a sheet of metal covered with absorbent cotton saturated with a solution of sodium salicylate. A current of about 20 ma. is turned on and kept up for about an hour. Static electricity in the form of sparks is of great utility in neuralgias. One of the methods of franklinization for allaying neuralgia and various forms of paresthesia is that of "sharp ends": the positive pole is connected with electrodes which have sharp ends, while the negative is connected with the earth or with an isolated plate for the feet. The electrodes should not be brought nearer the patient's body than at the distance of two centimeters. The conductors must be separated from each other by a distance of from five to eight centimeters. When everything is in readiness we shall find that light emanates from the ends of the electrodes and that ozone is given forth. The skin, when under the influence of the current, appears to give out a pleasant odor. This form of electricity is used chiefly in the treatment of neuralgias and paresthesias of all kinds. Lumbago is best treated by faradization. Very rapid vibration is advisable and the strength of the current is increased as toleration is established. Sponge electrodes are used: one is applied to the vertebræ, the other to the painful area. The latter electrode in the form of a brush is very satisfactory. Salicylic or lithium ionization is advised in lumbago, in rheumatism, gout, and vertebral arthritis.

(*b*) *Local Cramps, so-called Tics.*—In these affections the mode of employing the current is similar to that already described previously. A *labile application*, however, is the one most likely to prove beneficial. This is effected by applying one electrode at some indifferent point, while the other is moved slowly up and down over the region affected, without interrupting the current.

It is important to bear in mind that while the electrodes are *in situ* and the patient is beginning to feel burning sensations, they should not be removed, because by so doing the sensations in question would simply be intensified.

(*c*) *Paralysis of Peripheral Nerves.*—In the case of peripheral palsies therapeutic effects may be obtained by stimulating the muscles innervated by palsied nerves. The faradic current should be employed. The rules laid down for guidance in electrical examinations should be observed here. The negative electrode is to be placed on an indifferent point, while the positive electrode, supplied with an interrupting handle, should be applied to the affected muscles; the contractions obtained with each closure should be well marked. Both electrodes can also be placed simultaneously on the affected muscle, but if this is done a larger number of closures will be found necessary. The faradic current should not be used in cases in which there are spasms of the affected muscles. The galvanic current is to be used only when there is no response to the faradic. The cathode should be placed upon the affected muscles, while the anode is applied at some indifferent spot. During the passage of the current the cathode is kept moving to and fro over the diseased area without once being removed altogether. After each séance the current should be shut off before the electrodes are removed, especially when the face and neck are under treatment. Both currents, faradic and galvanic, can be utilized at the same sitting if a combination apparatus is employed. When there is no response to the galvanic or the faradic current, it is useless to attempt electrical treatment, and massage should be substituted. When the paralysis or atrophy is followed by contracture of the muscles, electrical applications to the affected muscles should never be attempted. Instead, the attempt may be made to produce a compensatory or counteracting effect by stimulating the muscles which have a function opposite to that of the diseased ones. Thus, for example, if the flexors of the forearm are permanently contracted, the extensors of the limb might advanta geously be stimulated, and vice versa.

Diseases of the Spinal Cord.—In the treatment of diseases of the spinal cord electricity affords a better outlook for improvement, if not for recovery, than does any other method of therapeutics. It can be applied to the cord itself or directly to the different organs dependent upon the parts of the spinal cord that are affected. As to the cord itself two kinds of galvanization are to be used: *stabile* and *labile*. In the first, the positive electrode is to be placed on the

neck, while the negative one should be applied to the lumbar region of the spinal column. A current of from four to eight ma. is then to be turned on for about ten minutes. In the second method the anode is to be applied, as before, on the neck, and the cathode is to be moved up and down along the spine without once being removed. This galvanization can be used only in systemic diseases of the cord, in tabes, or in chronic inflammatory conditions (posterior and lateral sclerosis, multiple sclerosis), but not in acute processes like myelitis or hematomyelia. In systemic diseases a longitudinal galvanization, in the form of stabile and labile applications, is indicated. By adopting this plan the current will be made to pass through the entire cord. In case a segment of the cord is diseased, as in transverse myelitis of a chronic character, a transverse galvanization is indicated. This may be carried out by placing one electrode over the spine, while the other is applied to the median line in front.

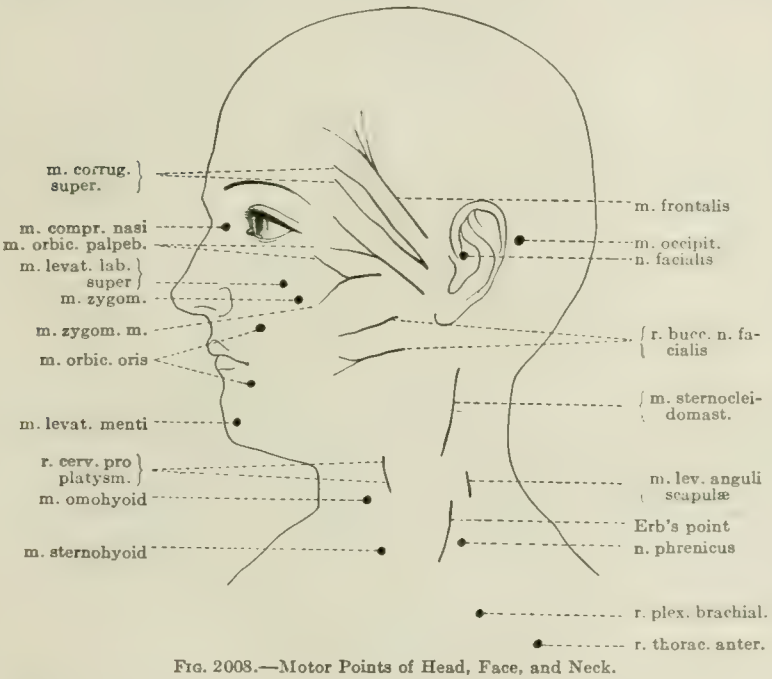


Fig. 2008.—Motor Points of Head, Face, and Neck.

The effect of galvanization of the cord is expressed by a betterment of its circulation and nutrition. Better results, however, will be obtained if the electrical current is applied directly to the organs affected by the disease of the cord. This is true, for example, of the palsies accompanying poliomyelitis or myelitis. In old palsies due to diseases of the cord the faradic current should be used. In cases of spasticity the anodal labile application of the galvanic current should be utilized. In mild palsies the galvanic cathode should be put in use. Paresthetic disturbances accompanying palsies can be relieved by the application of the galvanic anodal electrode or by using the faradic brush: the latter being especially indicated in cases of sharp pain.

In diseases of the spinal cord the sphincters of the bladder and rectum are often involved, and there are apt to be sexual disturbances. Cases have been reported in which good results were obtained by introducing into the urethra, as far as the bladder, an insulated electrode having the form of a bougie. Before turning on the electrical current (one of 10 ma.) the bladder should be half filled with warm salt water, and after a few minutes the current should be reversed. The faradic current is to be employed, and the external electrode is to be placed against the perineum, the lumbar part of the spine, or over the pubis. The galvanic current may also be utilized, but in that case the bougie-like electrode should be made the cathode. Good results have also been obtained from external electrization; the cathode of the galvanic current having been placed in these cases on the lumbar region and the anode on the perineum or the pubis. The most careful asepsis must be observed.

Impotence due to spinal diseases can be treated with the faradic brush, to be applied over the lumbar region, or with a labile galvanic current.

The question of electrotherapeutics in progressive muscular atrophies is intimately associated with that of *reactions of degeneration*. In each case a thorough investigation concerning the electrical reactions of atrophied and paralyzed muscles is absolutely indispensable, for the reactions of the diseased muscles to electrical currents will determine the nature and seat of the lesion. Also the prognosis of certain forms of paralyses depends almost exclusively upon the electrical reactions. It is therefore essential to say a few words in regard to the electrical reactions in muscular wastings and paralyses.

In diseases which involve the region of the peripheral neurones and which lead to degeneration of muscles one finds abnormalities in the electrical irritability of the affected nerves and muscles. These abnormalities present the following characteristic points:

1. *Quantitative* changes, namely: (*a*) diminution and entire loss of irritability (faradic and galvanic) of the nerves and of faradic irritability of the muscles; (*b*) increase and soon diminution of galvanic irritability of muscles. 2. *Qualitative* changes, especially: (*a*) slowness of galvanic muscular contractions, and eventually (*b*) deviation from the normal formula. If Ca represents the cathode (negative pole), An the anode (positive pole), C the closure, and O the opening, we shall have as the formula for normal nerve reactions to galvanism: CaCC> AnOC> AnCC> CaOC; and as that for normal muscle reactions: CaCC> AnCC> AnOC> CaOC. In disease the formulæ will be reversed.

The complicated anomalies of irritability, which accompany muscular degeneration and which disappear when the degeneration is followed by regeneration, were studied first by Erb (1868), Ziemssen, and Weiss; and finally Erb proposed that the corresponding symbol should be RD (reaction of degeneration).

The reaction of degeneration takes place in the following cases: 1. Diseases of the medulla with involvement of the nuclei of cranial nerves (such, for example, as the different forms of bulbar paralysis). 2. Diseases in which the cells of the anterior horns are involved (such, for example, as acute anterior poliomyelitis; so-called infantile palsy;* progressive muscular atrophy; hemorrhage and softening in the anterior horns; tumors, including gliomata; syringomyelia; transverse myelitis, and amyotrophic lateral sclerosis). In diffused foci of an inflammatory or a sclerotic nature, which have their seat in the anterior horns, we find RD in the muscles which derive their

* In infantile palsies of cerebral origin the electrical reactions show either a simple diminution or else no change whatever, but no RD.

nervous supply from the corresponding parts of the cord. 3. Diseases affecting the roots of cerebral or spinal nerves. Among these may be included meningeal processes of various kinds involving also the trunks, tuberculous disease of the columns, and tumors which have their origin in the roots or meninges. 4.

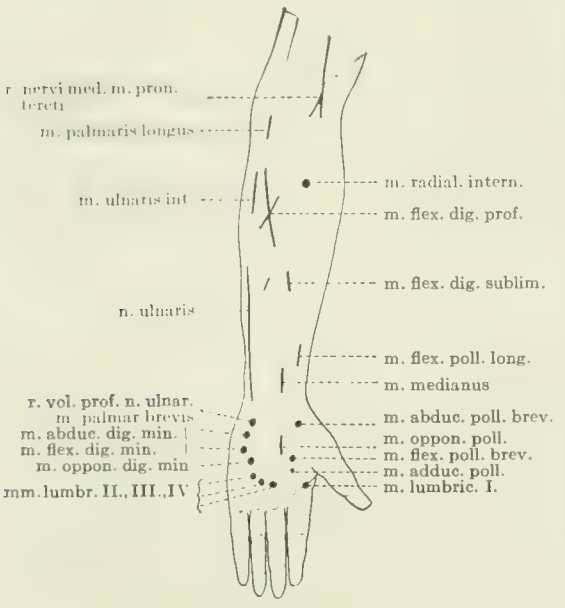


Fig. 2009.—Motor Points of Forearm.

Diseases of peripheral nerves: (*a*) Affections due to compression of the nerve (as, for example, the pressure palsies of the arms, peroneal palsy, and palsies of the ulnar and median nerves); rheumatic facial palsies; injuries of nerves in surgical operations. (*b*) Inflammation of nerves (as in the facial palsies which are caused by disease of the middle ear, and in the idiopathic palsies which are partly of a toxic nature—*e.g.* lead, arsenic, and alcoholic palsies—and partly

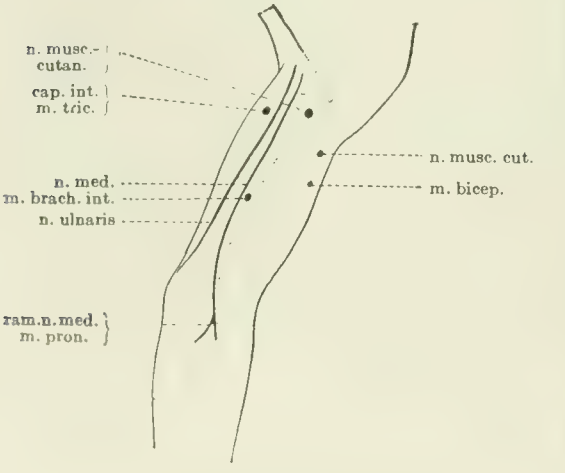


Fig. 2010.—Motor Points of Arm.

the result of infection—*e.g.* the palsies following diphtheria, influenza, etc. (*c*) Tumors of nerves.

The RD may be complete or partial. The complete reaction is observed in two classes of cases: those which are curable and those which are incurable. The curable cases may again be subdivided into the light and the more serious forms. A differential diagnosis between the incurable and the clearly curable cases can be made only after the lapse of eight, ten, or even fifteen weeks after the commencement of the disease. If by that time we notice a return of contractility

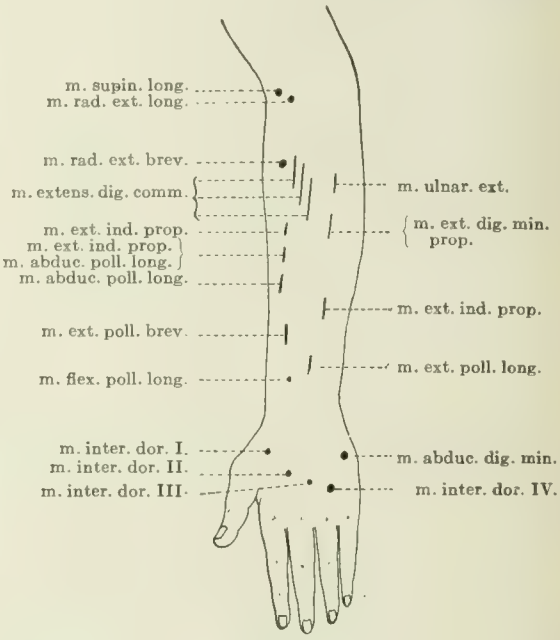


Fig. 2011.—Motor Points of the Extensor Surface of Forearm and Hand.

(under the use of a strong current applied indirectly through the nerves) in one or more muscles located in a region where previously the current had elicited no response, or if such contractility can be excited in these very muscles by a direct application of the faradic current, we may feel warranted in giving a favorable prognosis—*i.e.* the case in hand belongs to the curable variety. The more muscles respond to direct or indirect stimulation, the better is the prognosis. It is also important to watch the form of galvanic muscular contraction. If the galvanomuscular irritability is low, but the formerly slow contraction becomes rapid, the prognosis as a rule is good; but if it remains slow and becomes even slower, the prognosis is bad; it is probably a completely incurable form of paralysis.

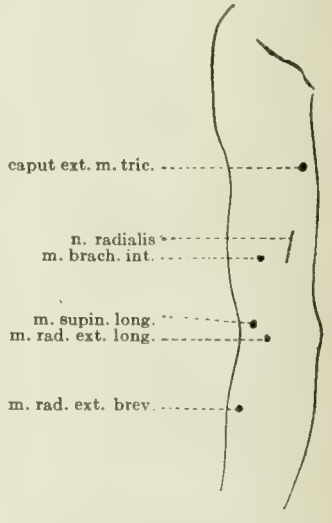


Fig. 2012.—Motor Points of Arm (Extensor Surface).

It is important to examine all the muscles of the diseased area by direct stimulation and indirectly (by application of the current to the nerves) in order to ascertain whether all the muscles innervated by the nerves in question contract or not.

We said before that progressive muscular atrophies should be treated with electricity. In progressive

muscular dystrophies, in which the palsy and atrophy are not due to involvement of the spinal cord, the faradic contractility is preserved for a very long time, and it is the last to disappear. The galvanic current should therefore be used in these cases, and a labile cathodal application should be made at the beginning

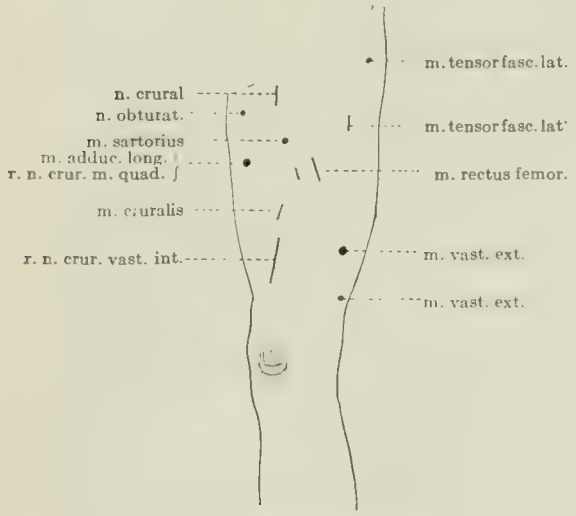


Fig. 2013.—Motor Points of Thigh.

and should soon be followed by the faradic current, or a combination of galvanism and faradism may be tried.

The accompanying figures (Figs. 2008 to 2016) will show the exact points where the electrodes should be applied in order to influence certain muscles and nerves of the face and four extremities in cases of paralysis and atrophy.

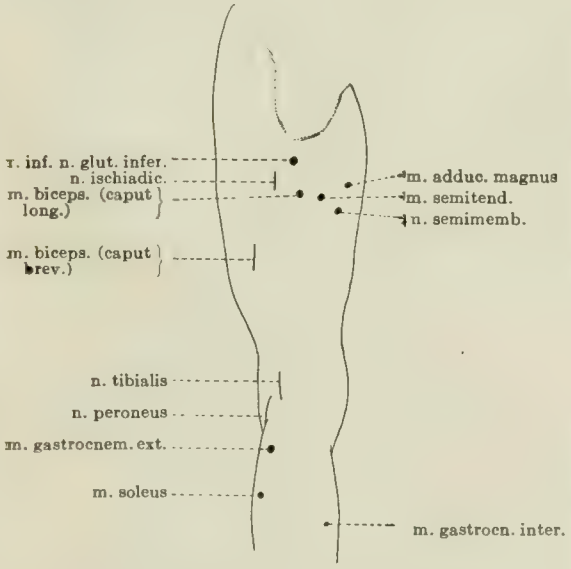


Fig. 2014.—Motor Points of Back of Thigh.

Diseases of the Brain.—Galvanization of the head has been resorted to in various diseases of the brain, such as hemorrhages, softening, inflammation, tumors, and atheromatous condition of the arteries, and even in psychoses of all varieties. The methods employed for influencing the brain are: 1. Longitudinal brain galvanization, in which the electrodes are applied to the forehead and occiput; the current may be either stabile or labile. 2. Transverse brain galvanization, in which the electrodes are applied either to the sides of the frontal bones, to the parietal protuberances, to the temporal bones, or to the mastoid processes.

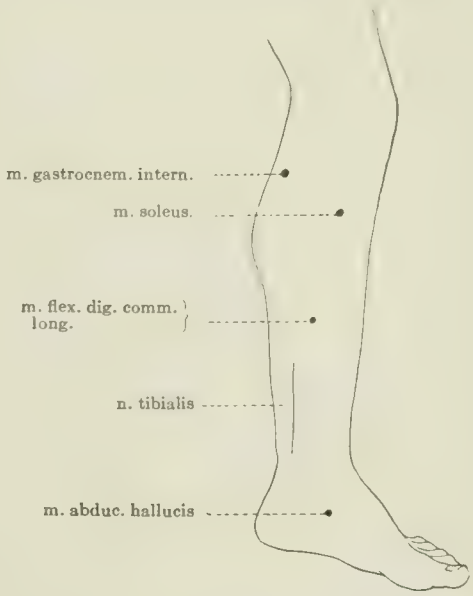


Fig. 2015.—Motor Points of Back of Leg and Inner Border of Foot.

The electrical applications to the brain are to be made very cautiously, and the rules above mentioned should be observed very strictly (see rules for applying electrical treatment). As a rule, applications to the

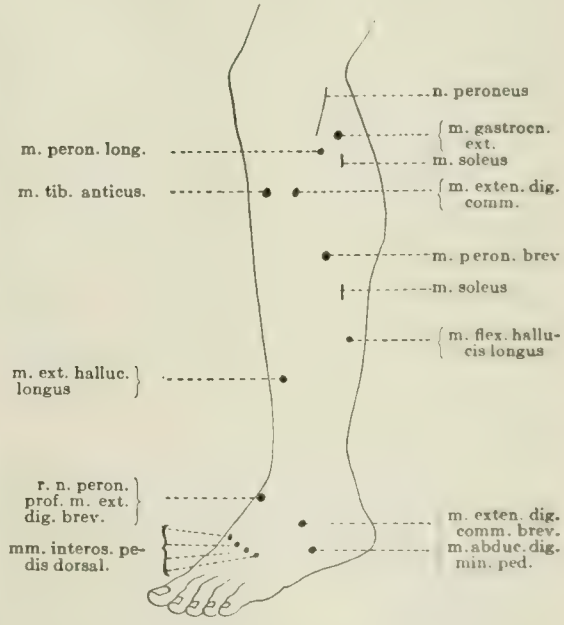


Fig. 2016.—Motor Points of Outer Side of Leg.

brain do not give any permanent result, and if any benefit follows, it is usually by relieving the headache.

The application should be made in the following manner: Place the anode on the forehead and the cathode on the neck or sternum, or place both

electrodes on the temples. The séance should not last more than five minutes, and a maximum current of 2 ma. should be used. One should rely rather on the sensations felt by the patient than on the strength of the current. Extreme precautions should be taken in galvanization of the head. Relief from headache can be obtained also by galvanization of the sympathetic system in the neck. The anode should be placed on the neck below the ear, behind the ascending perpendicular portion of the inferior maxilla, and the cathode in the jugular fossa. The cathode may also be placed on the corresponding spot on the opposite side of the neck. Very cautiously the current (from 1 to 3 ma.) is to be turned on for a few minutes.

Headache can also be relieved by means of static electricity, and the following are the methods: 1. *Static douche.* The positive and negative poles and conductors should be held apart and brought near to the patient's body as in the method of "sharp ends" (see above). By means of a short wire the negative pole is connected with the head-plate and the positive with the earth. With the aid of a screw the head-plate may be brought into more or less close proximity to the patient's head or adapted to special parts of the same. The distance separating the plate and the head should not be less than five centimeters. The nearer the plate is to the head the more intense will be the action of the current; and by isolating the patient's body by means of a foot-plate this action can be intensified. The séance should last for from five to fifteen minutes. 2. *Static air bath.* The same procedure as that already described on p. 899. The positive pole is connected with a foot-plate or chair, while the negative is connected with the earth. The séance lasts ten minutes; the patient may remain dressed. 3. *Flashes.* Same procedure as that already described. One pole is to be connected with the foot-plate, while the other (generally the positive one), which is connected with a button electrode, is made to approach the patient's body. Even at a distance of ten to thirty centimeters flashes and lights are noticed, which can be isolated and directed toward one special muscular part. The procedure causes some irritation. Salicylic ionization has been used with some success in headache of migrainic type. The negative electrode saturated with a twenty per cent. solution of sodium salicylate is applied to the head and in case of indurative headache to the painful muscles of the neck, the positive electrode to some indifferent place. A current of about 15 ma. is turned on and kept up for about thirty minutes.

As regards the treatment of cerebral palsies, good is sometimes obtained from the employment of the faradic current provided contractures have not already developed. In the latter case, however, the current should be applied to those muscles which have a function directly the opposite of that of the contracted muscles. For example, if the contracture puts the arm in flexion, a faradization of the extensors can be tried.

Functional Neuroses.—Electrical treatment in neuroses like hysteria or neurasthenia may sometimes produce a beneficial effect, not because of any specific influence upon the functional disturbances, but rather on account of its suggestive or psychic effect. Any method may be applied in these cases. The tact and ability of the physician in any given case will teach him to what particular method he should have recourse in order to obtain the best suggestive results, On the other hand, there are cases in which electricity, as an adjuvant to massage, will show its really beneficial effect of stimulation. For example, when a general muscular weakness is present, a general faradization will be found very useful. When the circulation is slow, not only in the skin, but also in other organs, a stimulus which will aid the metabolism, respiration, appetite, and general nutrition will be of great importance. The faradic current will produce, in addition to its direct effect on the skin, a reflex action on the central nervous system. The faradic brush or the roller should be applied to the arms, chest, back, and extremities alternately for fifteen or twenty minutes daily, or less often. General galvanization should also be tried. For this purpose the cathode should be placed on an indifferent spot, while the anode, of a smaller size, is to be applied to different parts of the body for about fifteen minutes, A very appropriate electrical treatment in functional neuroses is that by means of the electrical baths (see above).

As to individual symptoms in functional neuroses it is possible to influence them beneficially to some extent by electricity. Thus, for example, headaches, no matter of what variety, and insomnia can be relieved in some cases. The method of application is described in the paragraph which treats of diseases of the brain. Other functional symptoms, as paresthesia, hyperesthesia, or pain in the back, ovarian region, mammary region, etc., should be treated with the faradic brush or the massage roller. The anodal electrode of the galvanic current may also be tried.

Fig. 2017.—Apostoli's Bipolar Intrauterine Electrode for Faradic Current.

Electricity also shows its beneficial effect in *traumatic neuroses*, like writers', pianists', or tailors' cramp. The motor form of these neuroses, if they are not spastic, can be benefited by an appropriate electrical treatment. The principles are the same as those which govern any other paretic condition of muscles. Local faradization of the muscles, or cathodal galvanization or galvano-faradization, should be applied in the usual manner as described in other parts of this article. In case of *muscular cramps*, if electricity is to be used at all, faradization of the antagonistic muscles should be chosen as the proper procedure. *Tremors* of either a functional or an organic character, like those in multiple disseminated sclerosis, intoxication, etc., should not, as a rule, be treated with electricity, although good results have been reported from the use of electrical baths. The *vaso motor* or *secretory* neuroses may be treated with galvanization of the sympathetic nerve, but not much should be expected from it.

Diseases of the Uterus and its Appendages.—Fibroid growth is the most prominent affection of the uterus that can be treated by electricity. The object of this treatment is to relieve pain and hemorrhage, as well as to reduce the size of the tumors. It is supposed that currents traversing such growths cause an inhibition of their proliferating power, some degree of absorption through the lymphatic vessels, and a trophic stimulation of the healthy surrounding tissue. The discovery of the treatment of fibroid growths by means of electricity is due to Apostoli of Paris, France. He demonstrated in the '80's that electricity causes an actual arrest of growth and even retrogression of the fibroid tumors. This was verified by many surgeons, and some of them published cases which were characterized by the actual disappearance of the tumors. The best testimony

ever given in favor of Apostoli's treatment is that furnished by the eminent surgeon, Thomas Keith. In his work "Electricity in the Treatment of Uterine Tumors", which was written in collaboration with Skene, and dedicated to Apostoli, Keith gave the details of one hundred and six cases treated with electricity. In the introduction to this work he says: "For long we had doubts as to the permanency of the treatment in the early cases. The later work has been much more satisfactory. But now more than two years have passed since all operations were given up for this treatment; and our first patient writes—and no one could have had more hemorrhage—that she has been perfectly well all summer, climbing hills and rowing in a boat. Another of the early and doubtful ones, who could never bear a large dose of electricity, tells us: 'I am now in excellent

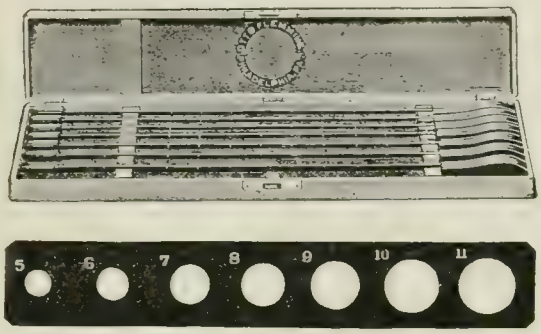


Fig. 2018.—Apostoli's Carbon-bulb Electrodes, with Scale.

health, without an ache or pain of any kind, and my periods are just a show, and nothing more, and give me no discomfort whatever. I hope you have been as successful with all your other patients as you have been with me. But it cannot be otherwise, for I am sure that no one could have been worse than I was with that awful hemorrhage.' This patient's importunity had almost driven me into doing hysterectomy for her. At first we fell into the natural mistake of trying electricity on every case that presented any symptoms, in some when the tumors were almost certainly sarcomatous, and even in one who was in the last stages of old cardiac disease. We know now that the cases best treated are those which are suffering much from hemorrhage—the more the better—cases in which something must be done; cases in which two or three years ago the question of operation of some kind would have been considered by us. This treatment, it must be remembered, is a new thing. We began it in comparative ignorance. Electricity is known by its results, and, working on the living body, progress and improvement are slow. In the following cases, therefore, are found some failures and some imperfect and incomplete cases: the marvel is rather that there are so few. Time and experience every day correct our want of knowledge and diminish these imperfections. No large uterine tumor has with us entirely disappeared under the electric treatment, but in four cases of small fibroids, three of which come into the present series, there is not now a trace to be found. The carrying out of this treatment faithfully to the end is not an easy matter, and old tumors that are large, and that have bled for many years, take a long time to improve. The treatment runs away with time, and it requires care and thought. To the surgeon, by far the simpler plan is hysterectomy and the removal of the ovaries. But Dr. Apostoli's treatment saves our patients from risk of life by operation, and saves them also from a horrid mutilation, the one thing that they all dread. We believe it to be the right treatment, and our patients must get it, however great the inconvenience and monotony it may be to ourselves. Though our results after hysterectomy show the lowest mortality of any yet recorded, and though we have had but a single death after removal of the ovaries for fibroid in almost one hundred operations, we reject even the minor operation in favor of Apostoli's treatment, and we reject hysterectomy altogether on account of the mortality that has hitherto attended it all over the world. The method given us by Apostoli is good, and it will endure. Since we began your treatment, now more than two years ago, we have ceased to perform any operation on the uterus by abdominal section. For myself I have always had grave doubts if I were justified in performing such operations at all, especially hysterectomy, for the mortality attending this operation is out of all proportion to the benefits received by the few. As time went on, and the number of operations became larger, my doubts as to whether I were doing right continued to increase, and that, too, in spite of the comparatively low mortality with which I was favored, more especially in my private practice. I never had any such doubts as to the propriety of performing ovariotomy, for if an ovarian cyst be left alone, death is almost certain, and even that is only reached after great suffering. With hysterectomy it is quite different. Hysterectomy is a hazardous operation for the removal of a tumor that of itself rarely shortens life. The minor operation, on the other hand—the removal of the ovaries—requires no surgical skill for its performance. It is a great mutilation to a woman, being simply castration; and women are beginning to find this out. It is not always successful in attaining its purpose, for you will find in these pages some cases narrated that were cured by electricity where operations on the ovaries had failed to give any relief. Your method thus came to me at a very opportune time. You have taken away from me those anxious doubts and fears that had so long vexed me. For long I had hoped much from electricity in the treatment of fibroids, but had only met with disappointment till your method was made known to me. It is in every way a new method, and it belongs to you and to no other. You have worked in the true scientific spirit. For five years you labored quietly at your clinic, kept up at your own expense, and open to all, before you made your work known. What have those to offer in place of all this who have so bitterly opposed this treatment; who with unlimited material stand aside and will not take the trouble to investigate the matter for themselves, but wait till some one else does it for them; who make only an outcry if by chance they hear of any accident during the progress of the treatment of any case, and who go frantic over the rumor of a death, or worse still, who proclaim they know of deaths that never happened. These men have absolutely nothing whatever to offer in the bad cases, and only hysterectomy in such tumors that will come out more or less easily, so as to be treated by the extraperitoneal method of operating. I have seen not a few cases of bad bleeding fibroids since I came to London; almost every one had consulted one or other surgical authority on the subject of operation. These were invariably told that nothing would do them any good but the removal of the tumor; but in their special case the local difficulties were too great, or they had let their strength go down too far for such an operation. The very feeble and bad cases, with masses of tumor blocking the pelvis, with absence of cervix,, and opened-out broad ligaments, would seem to be let alone. Hysterectomy then at best would appear to be a most doubtful remedy for a certain number of cases, and these not of the worst sort. On the other hand, the worse the case, the more feeble the patient, the greater the loss of blood, the more marked is the result of electrical treat-

ment. Given a woman with a large bleeding fibroid, blanched almost to death from years of hemorrhage, and see her some months after this treatment is completed, you would scarcely recognize her, the improvement is so great. Electricity in any form, when applied to the cure of disease, is set down as pure quackery by many medical men, simply because they know nothing about it, and won't take the trouble to learn for themselves what to many is rather a hard study. Every time that any disease can be cured without resorting to a bloody operation, such as hysterectomy, progress is made in our art, and there is a gain to humanity, while surgery is the better for being purged of a deadly operation. It may seem strange to some that after the results I got in hysterectomy—results that almost made it justifiable I should now begin to throw stones at the operation instead of trying still further to improve upon it. I would give something to have back again those sixty-four women that I did hysterectomy for, that I might have a trial of Apostoli's treatment upon them. What I now plead for is that, for a time, all bloody operations for the treatment of uterine fibroids should cease and that Apostoli's treatment, as practised by him, should have a fair trial."

*Method of Application.*—The positive pole is the one generally employed, especially in tumors accompanied by hemorrhages. The indifferent electrode (cathode) should be placed on the abdomen, and the active pole (anode) should be inserted into the uterus. In order to protect the os and cervix, the intrauterine electrode must be insulated. Apostoli uses a sound covered with a sheath of hard rubber. Of course asepsis and antisepsis should be strictly observed. Currents of from 30 to 50 ma. can be frequently repeated. Each séance should last for about five minutes (Apostoli). Stronger currents are permissible only after weak currents have been tried. The current must be taken off very gradually. After each séance the patient must rest for several hours. If on the following day there is pain or some fever, the electrical treatment should be abandoned. As to the effect of the negative pole, it is diametrically opposite to that of the positive; it produces a temporary congestion which will be very beneficial in non-hemorrhagic fibroids. The negative poles may therefore be expected to render very valuable service in fibroids accompanied with amenorrhea and dysmenorrhea. *En résumé* we will say, with Apostoli, that the positive pole should be utilized in cases in which there are hemorrhages, the negative pole in those in which there are no hemorrhages.

The intrauterine electrode should never be inserted until an examination has proved conclusively that pregnancy does not exist. An acute metritis or some purulent condition of the pelvis is also a contraindication to the employment of an intrauterine electrode. Among the tumors which do not yield to electrical treatment, we may mention the fibrocystomata and the myomata.

In cases of metritis and perimetritis, the employment of electricity does not, according to the majority of writers, prove of benefit, except to a certain extent in the chronic forms of these diseases. Apostoli believes, however, that even in the acute stage electricity is not contraindicated. The methods of procedure are the same as for fibroid tumors.

In diseases of the Fallopian tubes and ovaries again only the chronic forms should be treated with electricity. A vagino-abdominal or a combined intrauterine and abdominal application of a faradic or a galvanic current may be of use. As to the relative value of these two forms of electricity, galvanization, according to Apostoli, is much more powerful than faradization.

In cases of salpingo-ovaritis, not sufficiently ameliorated by intrauterine galvanism, Apostoli advises galvanopuncture, which treatment is more efficacious although more painful.

Amenorrhea and dysmenorrhea can be benefited by the employment of a strong primary faradic current preceded by a stabile galvanic current of about 30 ma. In the latter procedure the patient should be in the recumbent posture, with her body resting upon a large electrode, while the other electrode should rest alternately on the hypogastrium and the epigastrium. Static electricity with sparks drawn from the lumbar region of the cord, hypogastrium, and loins affords the quickest and most reliable method of treatment. General faradization, dorso-abdominal faradization, and the dry brush applied to the abdominal walls or to the soles of the feet, are reliable methods of application. When galvanization is used in these cases it should be applied either near the center of the body or along the spine; the current can be directed from the lumbar region toward the pubis. As to direct uterine applications, there is a general opinion that electricity applied not directly to the uterus, but to a distant part, exerts a better influence on the menstrual flow, except when the dysmenorrheic disturbances are due to stenosis of the cervix or to a deviation of the uterus. In the former condition the proper procedure is to introduce a galvanic cathode into the canal of the cervix; for the relief of the latter, Apostoli employs the current of the secondary spiral of a faradic battery, in connection with his bipolar intrauterine electrode (Fig. 1847), introduced into the uterus.

Subinvolution is treated by intrauterine faradic currents. Uterine and ovarian pain of a neuralgic character, accompanied by backache, should, according to Apostoli, be relieved by the faradic current. He recommends the employment of a secondary coil, of a long thin wire, so as to obtain as much tension as is convenient. He uses his bipolar electrode, introduced into the uterus, but external applications —one pole over the sacrum and the other on the perineum or in the groin—are often sufficient. Sometimes a better effect is produced by introducing one of the poles into the vagina.

Uterine growths have been treated with *fulguration method.* Rivière and Keating-Hart claim to have obtained very satisfactory results. It consists of streams or fine sparks from a high-frequency apparatus or a static machine. The current has apparently a thermic or chemical, or both, action on the malignant tissue and eliminates the latter.

Clark (*New York Medical Journal*, 1911) devised a method to which he gave the name of *desiccation.* It is apparently less painful and more effective than fulguration. The sparks are obtained from a static machine so devised as to give instantaneous control of the current. The sparks produce blanching of the diseased tissue if the latter is dry, and blackening if it oozes. Crusts or scabs are thus formed.

Diseases of Urinary Organs.—Electrical applications in paralysis and atony of the bladder due to a spinal affection are dwelt upon in the section relating to diseases of the spinal cord. The same method and rules can be applied in diseases of the bladder of a functional character.

In cases of chronic inflammation and stricture of the urethra the negative pole of the galvanic current should be utilized. The patient should be in the recumbent position, on his back. The indifferent electrode is to be placed on either the abdomen or the back. A whalebone bougie à boule, connected with the negative pole, is to be introduced into the urethra and pushed on until it reaches the painful spot or the stricture. The current should not have a strength above 3, 4, or 5 ma. As the current gradually increases in strength, the bougie will glide onward and pass through the previously contracted and painful canal. If after fifteen minutes the bougie does not

pass, defer the application. There should be an interval of at least one week between the applications. At each successive attempt a larger bougie should be used. This treatment of stricture depends for its success chiefly upon the action of the electricity, which causes galvanochemical absorption to take place—a process which is based upon the electrolytic properties of the tissues of the human body (see the paragraph relating to Electrolysis). No treatment will give more satisfactory results, in a case of irritability of the urethra, than this method of employing the galvanic current. Of course the gentlest manipulation is a necessary element in this sort of treatment.

Hypertrophy of the prostate may also be treated either by electrolysis or by the galvanocautery. The electrolytic treatment of this affection is the same as that for stricture of the urethra. An insulated bougie-shaped electrode, connected with the negative pole, should be passed through the urethra and its end allowed to rest against the enlarged gland. A current of 5 ma. is then allowed to pass for twenty minutes. The séance can be repeated every ten days.

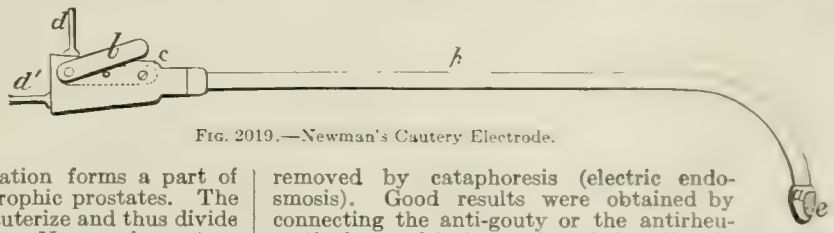

Fig. 2019.—Newman's Cautery Electrode.

The use of galvanocauterization forms a part of Bottini's operation for hypertrophic prostates. The object of this operation is to cauterize and thus divide the prostate. For this purpose Newman's cautery electrode is considered one of the best on the market (Fig. 0034). Tripier advises faradization for hypertrophy of the prostate. The procedure should be carried out in the following manner: An insulated sound is to be introduced into the urethra and a double bulbous electrode into the rectum, and then, after the current has been turned on, the latter is to be pressed against the prostate.

Nocturnal incontinence of urine is also benefited by electricity, good results being obtained by the use of either faradism or galvanism. One electrode should be introduced into the urethra and placed against the neck of the bladder, while the other is placed over the pubis.

Involuntary seminal emissions, spermatorrhea, and impotence are also affections which can be ameliorated or removed by the same method of treatment.

Under these circumstances the cathode should be introduced into the urethra and made to rest against the openings of the seminal ducts, while the anode is placed upon the perineum. In impotence it may be well to add to the procedure just described, galvanization of the spine and also applications of the faradic brush to the penis and scrotum. It seems proper to state here that two electrical instruments, already described in other parts of the Handbook, have been devised for the purpose of facilitating both the diagnosis and the treatment of diseases of the genito-urinary tract. I refer to the urethroscope and the cystoscope.

Chronic orchitis and epididymitis are benefited by the high-frequency current. The patient is placed on his back and holds in his hand a metallic electrode; the other electrode—a glass vacuum tube with an insulated handle—is applied to the affected side of the scrotum. The application should not last longer than ten minutes.

Gout and Rheumatism.—In these affections, which are associated with chronic inflammatory conditions of the joints and with degenerative changes, electrical baths (see above) are indicated. The baths may be either general, if several joints are affected simultaneously, or local, if only one or two joints of a limb are involved. In the latter case the affected member is placed in the bath, one pole of the battery is connected by a wire with a metallic vessel submerged in the water of the bath, and the other pole is placed on an indifferent part of the patient's body.

If with the diseased joint is associated muscular atrophy—which, in fact, often occurs—a local faradization of the muscles should be added to the treatment of the joint. Besides the baths direct faradization or galvanization of the joints is of great utility. Stabile unipolar currents, with the anode over the spinal origin of the nerves supplying the joint and the cathode over the joint itself, give good results. Bipolar applications are equally useful. When the faradic current is used, the higher its tension the greater appear to be its analgesic properties. In bipolar treatment the electrodes are placed on both sides of the articulation through which the electrical current passes. At the International Medical Congress of Berlin in 1890 Edison's experiments on the treatment of gout were reported by Bayles; it was demonstrated that the gouty concretions are removed by cataphoresis (electric endosmosis). Good results were obtained by connecting the anti-gouty or the antirheumatic drugs with the anode and then directly applying them to the affected joints. The much-desired metabolism, of transforming uric acid into urea, was obtained. The tophi, which in gout are composed of urate of sodium, are removed by galvanism, and particularly by the employment of the positive pole; the urates are split at the negative pole.

Muscular rheumatism, lumbago, and rheumatic torticollis may be treated by both galvanic and faradic currents. The method of application is the usual one. Bipolar faradic applications, strong enough to produce vigorous muscular contractions, are the best adapted for the relief of stiffness and spasm. The galvanic current, on the other hand, is more efficacious in relieving pain. The faradic brush also often affords relief in this class of cases. In muscular rheumatism static electricity, as a rule, affords no relief, but the static induction current, with its infinitely rapid succession of sparks, has the character of a faradic current of high tension and, as we mentioned above, it is likely to give relief for a long time.

Diseases of the Skin.—In the treatment of diseases of the skin electricity may be utilized in two different ways. If applied in a general manner it improves the general condition through the stimulation of the sensory terminations, and thus improves the trophic condition of the skin; while if applied locally it removes many uncomfortable symptoms, such as pain, pruritus, hyperesthesia. Electricity may also produce a caustic effect upon the skin, by depositing acids and alkalies on its free surface. For the production of a general effect, all the three varieties of electricity, static, faradic, and galvanic, may be utilized.

Static electricity is recognized as one of the greatest stimulants of metabolism, and at the same time one of the ideal cutaneous stimulants and sedatives. Faradic electricity acts as a stimulant. The galvanic current produces a sedative effect if a mild current (about 3 ma.) is applied continuously for five minutes. Care should be taken that the skin be slightly reddened; otherwise there may be electrolytic action followed by destruction of the skin. During the operation there should be no interruption of the current. The galvanic current, if applied in sufficient strength, can be used as a counterirritant. The

principle of cataphoresis, *i.e.* the property of the galvanic current to carry drugs under the skin for absorption, can be utilized in diseases of the skin. The anode should be saturated with the desired drug and applied to the spot where the action of the drug is expected. This method is particularly useful in parasitic affections of the skin; the positive electrode being impregnated with the parasiticide solution and placed over the diseased area. That mercury passes through the skin by this procedure was proven by Gärtner (*Rev. d'Electrothérapie*, 1892). Gautier (*Rev. d'Electrothérapie*, 1891) has proved it for copper, and has applied this treatment in lupus, actinomycosis, and sycosis. Copper needles connected with the positive pole are thrust into the diseased spots; during the passage of the current the copper becomes dissolved and forms, with the oxygen and chlorine of the tissues, an oxychloride of copper, which is highly antiseptic and caustic. The galvanocautery is utilized for the destruction of diseased tissues, and can therefore be applied in pathological conditions of the skin. Electrolysis is of more use. The tissues are destroyed by an alkali or an acid, whether we use the negative or the positive pole. Acids liberated on the positive pole coagulate the albumin, thus protecting the surrounding tissue from the freed acid. The cathode liberates alkali, which does not coagulate albumin, but acts as a destructive agent. The practical application of this principle in diseases of the skin is evident. A point to be considered is, that the electrode which produces the desired action upon the skin should be a needle and well insulated. The positive pole should be of platinum or gold, because other metals, through undergoing oxidation, leave an indelible stain on the skin. Electrolysis is particularly useful in acne, furuncle, carbuncle, lupus, and epithelioma.

Aneursyms.—In the treatment of thoracic and subclavian aneurysms in which medicinal aid fails to effect a cure, electricity has been tried with a fair proportion of good results. The employment of electricity in the treatment of aneurysms is based on the fact that a galvanic current passing through the blood coagulates it, through electrolysis. A clotting occurs around the poles, and then subsequently a further coagulation takes place and fibrin is deposited around the primitive clot. Ciniselli treated twenty-three patients, six of whom recovered. He operated with needles connected with both poles and introduced into the aneurysmal sac; every five minutes he reversed the current. Tripier and others advocate the insertion only of the positive pole, on account of its power to coagulate albumin. Stewart reports good results with continuous currents; the anode being introduced into the sac, and the cathode placed on the abdomen. The strength of the current may be gradually increased up to as high as 70 ma., but one should commence with 20 ma. Each séance should last about half an hour. Petit ("Dictionnaire Encyclopédique") treated 114 cases of aortic aneurysm with electrolysis; sixty-nine were improved. Aneurysms of the extremities were completely cured. Whether the positive pole should be inserted into the sac, or the negative, or both at the same time, as some authors advise, is a matter which has not been fully determined; but one should always bear in mind that hemorrhagic inflammation of the sac, with suppuration and embolism, may occur. In those cases in which the operation proves successful the tumor hardens and shrinks.

Alfred Gordon.

**Electrotonus.**—See *Tonicity*.

**Electuary.**—See *Confections*.

**Eleidin.**—The normal epithelium cells of the skin, as they come to lie farther and farther removed from the Malpighian layer, exhibit when they reach the level of the stratum granulosum fine granules of keratohyalin. These stain blue with hematoxylin. In the stratum lucidum these become translucent and are seen to be evenly diffused throughout the cells. The material is then called eleidin. According to many authors eliedin and keratohyalin are identical.

F. P. U.

**Elemi.**—Of the several resins which at one time or another have been sold under this name, that in use at present is the one known as Manila elemi, and comes from the Philippines.

Elemi exudes from incisions in the bark of one or more species of *Canarium* (fam. *Burseraceæ*). *C. commune* L., of India, yields one variety, but it is apparently not that now in use, which comes chiefly from the island of Luzon.

Elemi is a soft, translucent, grayish-white or yellowish substance, of pleasant aromatic odor, and rather terebinthinous taste. It comes in large cakes or masses, often very much contaminated with dirt, chips, and leaves.

Composition.—According to Flückiger it contains ten per cent. of *essential oil*, which may be separated upon fractional distillation into six portions, all of the turpentine series, $C_{10}H_{16}$, or $C_5H_8$. The remaining resin is a complex mixture, from which several crystalline, resinous substances—*amyrin*, *bryoidin*, *breidin*, etc.—and amorphous resins have been separated. *Elemic acid* is finally another ingredient.

Action and Use.—Elemi is a local stimulant, like turpentine and resin, and is put to the same uses. Its only employment here, and that quite rarely, is as an ingredient of plasters and ointments. *Unguentum Elemi* was made of elemi one part and simple ointment four parts.

W. P. Bolles.

**Elephantiasis.**—*Synonyms:* Elephantiasis Arabum; Barbadoes leg; Morbus herculeus; Spargosis of the Egyptians; Pachydermia; Sarcoma mucosum; Tropical big leg; Bucnemia tropica; Hypersarcosis; Phlegmasia malabarica; Mal de Cayenne.

Definition.—A chronic endemic or sporadic disease, characterized by a progressive enlargement of particular portions of the body, due to hyperplasia of the connective tissue of the skin and subcutaneous structures, preceded by a local disturbance of the circulation especially in the lymphatic vessels, that terminates in swelling, edema, induration, hypertrophy, more or less pigmentation, in the development of fissures, and growth of the papillæ.

Owing to its great antiquity and the prominence awarded it by the earliest medical authorities, elephantiasis must be regarded as a disease of phenomenal interest. Its name implies that it originated in Arabia; indeed, medical history states that it first prevailed in that country and was of common occurrence. Formerly the term, practically unlimited in its application, failed to express with even approximate accuracy the various forms and phases of the disease. It apparently embraced all the morbid conditions of the human body which involved the enlargement of a specified part, and pointed particularly to the condition described as lepra græcorum. Truly, this was most unfortunate as it was many times applied to lesions of totally different pathological characters. Happily, however, the employment of this generic term for diverse morbid processes has finally been discountenanced, being at present confined to a single disease.

While elephantiasis is a typical pandemic disorder, having wide differences, it is either endemic or

sporadic in its distribution, differing symptomatically as to its exciting causes, but having like results in all cases.

The sporadic form is world wide in its distribution. The endemic form is essentially a disease of the tropical and subtropical regions, appearing most frequently in Africa, India, the Indian Archipelago, the West Indes, Mexico, and Central and South America. The endemic type is rarely encountered beyond the 35th degree of North and South latitudes. In some places it is rare, in others it is very common, affecting about five per cent. of the entire population, while in some of the South Pacific Islands nearly one-half of all the inhabitants are its victims. In the United States it is very rare, occasional cases occurring in the Southern States; while in the territorial possessions it is very common, being frequently observed in the Panama Canal Zone.

The two types of the condition differ radically as to etiology, symptomatology, and course; they cover a multitude of hypertrophic conditions, the result of congenital elephantiasis, telangiectodes and lymphangiectodes, other obstructions of the lymphatic system including chronic phlegmasia dolens and hypertrophy originating in chronic eczema and varicose veins.

Endemic Form.—This form, filariasis, elephantiasis tropica, declares itself somewhat suddenly, and is accompanied by pain and inflammation of the parts affected, more or less well-marked febrile symptoms, the so-called elephantoid fever, which is usually characterized by a prodromic stage, generally following overexertion or injury, chills, high fever, and gastric disturbances.

The inflammation is of an erysipelatous character, and chooses the lymphatics and blood-vessels as its points of attack. Often the lymph glands of the groin and armpit become swollen and extremely sensitive. A lymphatic streak of a rose color is frequently seen to traverse the skin which, when palpated, seems to present a line of knots; the region involved becomes reddened, hot, painful, edematous, and swollen.

In a few days the constitutional symptoms subside, so also, as a rule, does the swelling; a slight thickening, however, may remain. The further course of the disease is marked by repeated attacks, at irregular intervals, of lymphangitis and lymphatic edema. These may be repeated once or twice in a single month, or may be delayed for a whole year. As a rule, the oftener the attacks occur the less intense is the general reaction; while, on the other hand, there occurs, each time, additional hypertrophy of the region affected. Finally the affected part becomes permanently enlarged, hard to the touch, and dark in color, with folds beneath which dirt and offensive discharges collect; hence the comparison, if the disease affects the lower extremity, to the elephant's leg. In the interval between any two attacks, if protracted, the swelling somewhat recedes, but may afterward increase. As a consequence of the recurrent inflammation, enormous and persistent hypertrophies result. Sometimes there are slight tension and firmness of the affected parts, but at other times they show a discoloration consisting of various shades of red. After a few attacks, a fold of skin, when pinched, reveals an appreciable thickening. Repeated attacks result in still further thickening of the skin and subcutaneous connective tissue; the skin becomes harder, firmer, non-resistant, and more intensely fastened to the substratum. In extreme cases, the deep fascia, the sheaths of the blood-vessels, and the periosteum are involved. The condition is furthermore favored by the stasis of the lymph in the channels and obstructed glands, resulting in a dilatation of the lymphatic trunks which become indurated, tough, and stringy. Ultimately, they and the surrounding connective tissues fuse together into a uniform, hard mass.

The changes which take place upon the exterior of the integument, after the lapse of a year or more, are manifold. At first the skin is usually dry, shiny, smooth, and tense; a little later it becomes discolored and is found to be rough, tawny, ichthyotic, and pigmented. The natural folds and furrows are greatly exaggerated, and often present irregular fissures especially pronounced at the bases of the folds under which the epidermis is apt to become macerated and decomposed, as a result of which there is an offensive discharge. The papillary layer is frequently modified in that it may be uniformly thickened like the whole skin, or it may occur only at certain points, forming the verrucous projections often encountered about the arch of the foot or between the folds of the integument. While the structural change of the papillary layer is not always the same, it may be said that thickening of the epidermis is generally associated with hypertrophic papillæ.

This disease is calculated to give more or less annoyance to the patient, not alone because the parts are cumbersome, but for the reason that great deformities of the toes may result from atrophy and dislocations. The nails, too, may contribute to the characteristic discomfort by undergoing some kind of degeneration. Occasionally even the bones show a change. Osteophytes may arise, particularly near the insertion of a muscle or sinew, or at the borders of the epiphyses, and eventually the bone undergoes necrosis and ulceration. In addition to interference caused by the deformity, the function of the limb becomes greatly impaired from the hypertrophy of the structures of

Fig. 2020.—Elephantiasis Tropica. (From a photograph by a former surgeon of the Marine Hospital Service, in the collection of Dr. Charles Jewett.)

the soft parts and from atrophy of the bones and muscles. The resulting inconvenience is considerable, especially when the disease affects the lower portion of the leg. Other local discomforts may arise, secondary consequences of the disease, that greatly aggravate the suffering of the patient. Again, severe and continuous pain, usually of a neuralgic character, may

accompany the disease. Occasionally elephantiasis may be associated with complications; they consist, as a rule, of suppuration of the inguinal glands, and of cellulitis with subsequent abscess formations.

Sporadic Form.—This, like the endemic form, very often declares itself in recurring attacks of lymphangitis, but differs from it in these particulars: the con-

Fig. 2021.—Elephantiasis of the Scrotum. Weight of tumor after removal, 120 pounds. (From a photograph by a surgeon of the Marine Hospital Service, in the collection of Dr. Charles S. Jewett.)

stitu tional symptoms are not usually as severe, and the enlargement is more equally distributed about the limb and not so often associated with the section below the knee. Cases resulting wholly—or nearly so—from chronic irritation without any acute inflammatory signs, would seem almost to constitute an entirely different class. However, these two types—the endemic and the sporadic—are so similar clinically that they must be considered as one. It is not difficult to see that repeated inflammations have greatly interfered with the venous and lymphatic circulation; the limb has therefore been chronically congested and a superabundance of lymph has been constantly present in the subcutaneous cellular spaces. This condition finally becomes more pronounced and results in the hypertrophy and induration so characteristic of elephantiasis. In rare cases the acute and chronic inflammations, which may be regarded as the cause of the disease, are wanting.

Regional Symptomatology.—The particular portion of the body most frequently attacked is the leg, yet the hypertrophy frequently appears elsewhere, as, for example, in the scrotum, penis, labia, hand, arm, face, and ears. Apart from the extremities it may be stated that it is most often met with in the scrotum which has been known to attain a weight of more than one hundred pounds, and actually to reach the ground. When the male genitals become the seat of the difficulty, we have symptoms and complications peculiar to these parts. The symptoms referred to, in addition to the constitutional ones and the recurring attacks of lymphangitis, are both systemic and local. For besides the usual chills and fever, one often encounters nausea and vomiting, associated with severe pains in the groin, radiating from the spermatic cord, with subsequent swelling of the locality. The attack may be acute in consequence of the disturbance in the circulation, this being especially true when the inguinal glands are greatly inflamed and swollen, and when there is a chronic inflammatory affection of the penis and scrotum. Strictures, urinary fistulæ, and incontinence of urine are frequently the source of the disease. The cutaneous covering of the scrotum and penis soon loses its sensitiveness and becomes indurated, rough, and rugose. The prepuce is lengthened and thickened and the skin gradually becomes hypertrophied. When the scrotum is involved, the raphé and the natural folds and furrows are greatly exaggerated; beneath these, dirt and dribbling urine from a retracted penis collect, and give rise to the formation of excoriations, fissures, and ulcerations accompanied by offensive discharges. One also finds as complications hernia, hydrocele, hematuria, chyluria, and a varicose condition of the lymphatics of the scrotum.

Elephantiasis of the scrotum due to filariasis, is characterized by the presence of enlarged vessels arranged in lines or groups, which vary in diameter from a pinhead to a bean, and which, being opened, exude a pinkish, milky fluid which readily coagulates.

Fig. 2022.—Elephantiasis of the Leg Resulting from Varicose Ulcer.

In its incipiency it is attended with chills, fever and erysipelatous inflammations; the inguinal glands on one or both sides are swollen; and, sometimes, there is inflammation of the testicles.

Elephantiasis of the female genitals, in the temperate zone, is more frequently met with than its congener in man, but in the tropical and subtropical climates these organs are less often assailed. The

parts generally affected are the vulva, the labia majora, less often the labia minora, and rarely the clitoris. The sporadic variety is remarkable in that it is comparatively mild and seldom presents the intense features found in the endemic type. In the former variety the development of the disease may be slow and painless, or very rapid. It is usually characterized by symptoms which indicate that it is the result of some irritation, as onanism, or of some local affection, as syphilitic inflammation, which, in addition to the irritation, obstructs the circulation of the lymphatics. Benign tumors or congenital malformations may serve to explain the subsequent hypertrophy.

The entire vulva is not always involved, but usually the labia majora become affected. Should the lesser labia fail to escape the influence of the disease, they will often become the seat of a spherical or pear-shaped tumor, for the most part small, although sometimes attaining considerable size. The skin of the genital region may become either smooth and somewhat tense and firm, or wrinkled and covered with dilated sebaceous glands with gaping orifices; or it may show warty growths arising from the enlarged papillæ. In the latter case the entire surface of the vulva as well as the perineum may be covered with these warty growths. The surface, owing to the presence of distinct and hypertrophic papillæ, reveals numerous rifts and fissures. The development of the disease in these parts is generally quite slow, a number of years being necessary to produce tumors as large as a hen's egg, but at times the pathological change occurs more rapidly, and then the masses may attain enormous dimensions. Even when these growths are small, the patient often suffers from rhagades, fissures, and ulcerations, which, if not actually painful in themselves, are always troublesome by reason of the irritation caused by the acrid excretions. The mucous membranes of the urethra and vagina also, under these conditions, often throw out a discharge which is of an irritating character.

Fig. 2023.—Elephantiasis of the Upper Lip and Portions of the Face. (Hyde and Montgomery.)

Elephantiasis of the face and head usually presents a lobulated appearance without well-defined borders. It generally results from frequent attacks of erysipelas, or it follows a chronic eczema, or, finally, it may be due to traumatism. The entire face may be affected, or only a single section, as the forehead, ears, lips, or nose. Elephantiasis of the mammæ occurs only in women and never before puberty. It generally manifests itself during pregnancy or lactation and is almost invariably of the endemic type. In the tropics the female breast has been known to develop into a colossal tumor, large enough to extend down to the patient's knees, and at the same time the affected skin has shown a marked tendency to ulcerate.

Elephantiasis is sometimes congenital. This form resembles the sporadic or the endemic variety in its anatomical characteristics, but differs from them not only in origin but in general symptoms. Instances of congenital lymphangiectatic macroglossia and macrocheiria are occasionally met. Cases of circumscribed lymphangiectasis of the skin are also sometimes encountered, and from their resemblance to tumors they are classified as lymphangiomata. Well-defined elephantiasis due to congenital causes is not frequent in temperate climates. Typical instances of the malady in tropical countries have been made the subject of interesting monographs by Moncorvo of Rio de Janeiro, in which he graphically depicts the facial and manual deformities. He discovered the presence of streptococci in the blood and he believed that they were the exciting cause. They found their way into the maternal circulation, as he believed, through the placenta, from a previous injury to the abdomen. Some authorities attribute the development of this peculiar disease to the filaria or its embryos, others regard it as the result of hereditary syphilis. In a sporadic case which was reported by Dr. Ernest Wende, and which developed in intrauterine life, it was found, upon microscopical examination, that the connective tissue of the skin was greatly thickened, especially in the papillary layer; the sweat glands were distorted; the muscles had undergone fatty degeneration; the walls of the blood-vessels were thickened and some of them were obstructed. Similar changes were met with in the lymphatics. The lymph spaces were enlarged and dilated. Round-cell infiltration was present. No filariæ or embryos were found. It was concluded that the etiology of

this disease is not subject to a single law, as now held by some authorities, but is due to several distinct causes. Fig. 1859, copied from a photograph, shows the gross manifestations of the disease in this particular case.

Etiology.—Elephantiasis is a secondary rather than a primary disease. It may appear spontaneously, or be congenital or inherited, or it may be acquired. Elephantiasis of the endemic or tropical form occurs at all ages, but more frequently in adult life. It attacks both male and female in the ratio of four to one, undoubtedly due to greater exposure. While developing in all climates and countries it is more common among the natives of tropic and subtropic islands and coast regions. Sir Joseph Fayrer states that in India, if the disease occurs among Europeans, it is always among those who possess an admixture of native blood. On the other hand, Manson says that racial peculiarities do not play a vital part in the problem, but that the Europeans, owing to their education and habits, are less exposed and therefore less liable to contract the disease.

Many observers emphasize the possibility that heredity is either the direct cause or that it creates a predisposition to it. In support of this theory, it has been observed that the disease has existed in the same family for several generations. It should be borne in mind, however, that the individual members of such families are usually exposed to the same general influences of climate, habits, and mode of living. Proximity to mosquito-breeding regions, unsanitary surroundings, and constant exposure to the bite of infected mosquitos are the conditions which favor the development of endemic or tropical elephantiasis.

Fig. 2024.—Congenital Elephantiasis. (Dr. Ernest Wende.)

The consensus of opinion of a large number of investigators is that the presence of the *Filaria bancrofti* in the blood and lymphatic vessels from the bite of infected mosquitos (Anopheles, Culex, and Panoplites) is the primary cause of this form of elephantiasis.

Some sporadic or non-tropical cases seen the world over, known as elephantiasis non-parasitica, obscure in origin, long in duration, and extensive in development, are not due to the filaria—yet they have attacks of lymphangitis and may, or may not have fever very similar to the elephantiasis of the tropics.

In considering the etiology, a study of the sporadic form gives a clearer comprehension of the causes of elephantiasis. In this form are included all those pathological factors producing acute and chronic lymphangitis, such as erysipelatous or eczematous inflammation of the skin involving the lymphatic vessels. The question arises whether these repeated attacks of erysipelatous inflammation constitute a true erysipelas, or a lymphatic process peculiar to elephantiasis alone. The consensus of opinion is that the streptococcus discovered in several of these cases is different from that which produces genuine erysipelas. However, a true erysipelatous condition may precede elephantiasis, the local conditions being favorable, as is often the case when ulcers, fissures, or lymph fistulæ are present. It is difficult to ascertain the cause of the many cases of elephantiasis that occur sporadically in our climate, for the affection is apparently occasioned by various factors favoring recurrent inflammation and obstruction of a lymphatic edematous character. For instance, when the disease begins in the lower extremity, any local process or factor calculated to impede the venous circulation—as by compression from scars, or by means of a thrombus resulting from a phlebitis, or even by means of a frost-bite—may possibly give rise to the difficulty. In fact, it may be caused by any decided inflammation of the soft parts; to this category belong chronic eczema, syphilis, lupus, ulcers, and fistulæ. The destruction of a lymph gland, as after the removal of the axillary or inguinal glands for secondary carcinoma or for tuberculosis, may be followed by elephantiasis of the part tributary to the glands.

Pathology.—The pathology of this malady is peculiar in that, irrespective of the specific causes—of which there are a number—the resulting changes are invariably the same.

The peculiar characteristics are a cell proliferation and hypertrophy which involve in varying degrees all the structures of the affected parts. Hyperplasia of connective tissue and hypertrophy of lymph-vessels perhaps constitute the most prominent features of the disease and produce the bulk of the enlargement; the new fibrous tissue may be very poor in cells or it may resemble a cellular granulation tissue. The lymph capillaries are dilated with marked new formation of lymph-vessels and thickening of the walls of the existing lymphatics, and there is a moderate increase of blood-vessels. Numerous plasma-cells are scattered through the tissue and areas of lymphoid infiltration are numerous. The process involves the true skin, blood-vessels, lymphatics, and the structures of the nervous and muscular systems. The various layers of the skin become so matted by reason of the enormous increase in the fascicles of

the fibrous tissue that they can hardly be distinguished. The corium is greatly thickened and indurated, and in certain localities the process is so marked as to produce verrucous elevations. The sebaceous and sweat glands, as well as the hair follicles, are at first usually unchanged, but subsequently are widely separated; in consequence of hypertrophic pressure they may become atrophied and scarcely perceptible, or plugged and their walls thickened. The fasciæ and intermuscular septa are greatly augmented, and present evidence of fatty degeneration.

Endemic or tropical elephantiasis is known to be caused by the partial or complete obstruction of a lymphatic vessel or gland by thread-worms of the genus Filaria or their embryos; these are found in the peripheral lymph vessels in elephantiasis of the leg, scrotum, vulva, arm, mammæ, and other regions. The question of how the parasite produces the obstruction is not fully understood; the relation of filaria to elephantiasis is based chiefly upon circumstantial evidence; it is possible that local conditions incident to the geographical distribution of the Filaria have resulted in producing several species, each causing special manifestations, the *Filaria bancrofti* bringing about those changes in the lymph circulation culminating in elephantiasis.

*Filaria bancrofti* are male and female white or brownish worms, transversely striated; the female is longer than the male; they measure 44 to 95 mm. in length, and 0.1 to 0.26 mm. in diameter; the female is viviparous with vulva 0.66 to 1.3 mm.

Fig. 2025.—Filaria Bancrofti. (Photomicrograph by Dr. Harvey R. Gaylord.)

from the head and the anus 225$\mu$ from the tail; the male has two spicules about 0.5 mm. long at anogenital pore 138$\mu$ from the tail. The larvæ are 300 to 340$\mu$ long by 6.6 to 11$\mu$ in diameter; they are provided with a sheath and sharply pointed tail. They appear in the peripheral circulation with marked periodicity, being found only during the habitual rest time of the patient; a change of the usual rest period is accompanied by a similar change in the period of the appearance of the larvæ; they are abstracted from the blood by the mosquito in which they undergo development; after fourteen to forty-one days, according to the temperature, they reach a stage in which they may be transmitted to man by the bite of the mosquito. Nothing positive is known of the biology of the adult worm after entering man, although in the opinion of Manson, whose work on the Filaria is the base of all subsequent knowledge, the parent worm occupies some portion of the lymph channel, at which place its larvæ are discharged, to wander through the lymph glands and general circulation. It has not been shown with absolute certainty whether the larvæ which appear periodically come in freshly from the lymph-vessels and then die, or whether they assert themselves alternately in the blood and lymph. The discovery of larvæ in the blood depends very much upon the precise time of examination and often proves to be negative. So long as the patient is active, no specimens of the parasite are likely to be discovered; but usually a moderate number of larvæ can be found after the patient has been in bed for a short time.

Treatment.—In the endemic type prophylaxis is more important than treatment. Prophylaxis of filariasis is secured by the elimination of the mosquito, hence persons residing in mosquito-infected regions should invariably rest or sleep under netting. This injunction applies with greater force to one either supposed to be infected or who is actually suffering from filariasis. All cases may be greatly benefited by a change to a country that is free from the infection; for it has been observed that even if the disease is far advanced the severity of the paroxysmal attacks will be lessened by removal to a different country.

Surgical interference of one kind or another has never accomplished any definite result in these cases, as the larvæ which are usually lodged in the glandular structure after being hatched, enter the general circulation of other portions of the body.

Potassium iodide, gallic acid, methylene blue and ichthyol are used for supposed specific effect upon the parasite but their value is problematic. The measures commonly adopted in connection with this condition, especially when preceded by chills and fever, are such as will most successfully combat inflammatory processes. The effect of such remedies will be to counteract the fever, lessen exudation, and diminish stasis. The medicines generally employed for this purpose are quinine, salines, phenacetine, or any other suitable antipyretic, while soothing and astringent lotions, like lead-water and opium, zinc oxide, and boric acid may be applied locally until the inflammatory action has subsided. After the intercurrent attacks, tonics, such as iron, cod-liver oil, strychnine, and mineral acids, may secure beneficial results.

In the sporadic type which is met with in this country the treatment consists in counteracting the cause. If the disease is the result of an ulcer on the leg, this should be promptly healed, its excrescences removed, and the limb maintained in an elevated and horizontal position. Afterward it should be methodically compressed with a rubber bandage beginning with each separate toe, then the foot and ankle, and lastly the leg, so as to diminish the edema. When the elephantiasis has reached such proportions that bandages no longer serve, ligation of the arteria femoralis and of the iliaca externa may be performed; in certain instances these measures have proved effective and they should be tried in extreme cases. In acute attacks the parts may be punctured—in order to lessen the effusion by providing an escape for the fluid—and antiseptically dressed with an astringent lotion or ointment. In a few instances nerve-stretching and partial excision of the sciatic nerve have been followed by beneficial results. Amputation of the leg has also been resorted to, but the operation has not been characterized by the same success as has attended amputation in other regions.

In elephantiasis of the scrotum the removal of the offending mass by the knife sometimes becomes indispensable. The mortality resulting from heroic treatment is comparatively small. Before operating, Fayrer recommends drawing off the blood by placing

the patient on his back, elevating the tumor and compressing it with an elastic bandage. The incision is to be made alongside of the cord and at the root of the penis. The skin is reflected and the cord, testicles, and penis protected by turning them out; the mass is then quickly removed, only a few bold incisions being required.

In that of the female genitals, almost without exception, surgical interference is demanded. For this purpose either the knife or the galvanocautery may be employed. The latter method is simple and especially adapted to cases of hypertrophied labia.

In cases of chronic erysipelatous or eczematous inflammations, or in recurrent local lymphangitis both autogenous and stock vaccines have been used with some reported success. The object being to produce an immunity to the strains of the active organisms and thereby prevent further development of the elephantiasis.

Prognosis.—The prognosis depends upon the particular form of the disease, and upon the complications. It is evident from what has been said that the disease is not necessarily fatal—even the endemic variety vastly improves under a change of climate. This is likewise true of sporadic cases. Both surgery and medicine have comparatively cured even aggravated cases. The duration of life is not usually shortened by elephantiasis, since it exerts no detrimental influence upon the general constitution. Death rarely ensues except in those cases complicated by suppuration or septic infection.

The necessary literature relating to this subject is to be found in the following books: A. von Winiwarter: "Chirurgischen Krankheiten der Haut;" Hyde: "Diseases of the Skin," "Twentieth Century Practice of Medicine," vol. iv.; Allbutt and Rolleston's "System of Medicine," vol. ii.; "La Pratique Dermatologique," vol. ii.; Osler's "Modern Medicine," vols. i. and iv.; "Castellani and Chalmers; "Manual of Tropical Medicine"; Manson: "Tropical Diseases"; and the *Lancet* and *British Medical Journal*, 1880 and following years. Grover W. Wende.

**Elixiria.**—Elixirs are fluid preparations, sweetened and aromatic, containing in solution one or more medicinal substances, and more or less alcohol. They are intended, presumably, to serve as a vehicle for the administration of other drugs and preparations; and as they contain a considerable precentage of alcohol they should be well diluted before being administered. As elixirs contain but a small quantity of some remedial agent in a large quantity of alcohol they are very conducive to the formation of the alcohol habit. Perhaps it is to this alcoholic content that they owe their popularity among a certain section of the public. That this popularity is not shared by the medical profession is shown by the fact that there are only three of these elixirs in the United States Pharmacopœia; the British Pharmacopœia has no official elixir, but mentions one (*elixir of vitriol*) as a synonym of aromatic sulphuric acid. On the other hand, the National Formulary gives eighty-eight of these slightly medicated tipples.

Elixirs of the U. S. Pharmacopœia.

| | Composition. |
|---|---|
| Elixir Adjuvans (Adjuvant Elixir) | Fluid extract of glycyrrhiza 120, and aromatic elixir to 1000. |
| Elixir Aromaticum (Aromatic Elixir) | Compound spirit of orange 12, syrup 375, purified talc 30, and alcohol and water each enough to make 1,000. |
| Elixir Ferri, Quininæ et Strychninæ Phosphatum (Elixir of the phosphates of iron, quinine, and strychnine) | Ferric phosphate 17.5, quinine 8.75, strychnine 0.275, phosphoric acid 2, ammonium carbonate 9, alcohol 60, acetic acid 28.65, and ammonia water, water, and aromatic elixir, each enough to make 1,000. |

R. J. E. Scott.

**Elm, Slippery.**—See *Ulmus*.

**Embelia.**—The fruit of *Embelia ribes* Burm. (fam. *Myrsinaceæ*). The fruits of this Indian shrub are nearly as large as black-pepper fruits, globular, slightly beaked, dull red and striate, becoming brown on keeping. They are said to be used to adulterate pepper. The drug is largely used in its home as a stomachic, carminative, stimulant, and anthelmintic, and also as a parasiticidal application to ringworm and similar affections. It appears to be specially useful as a tænicide. Although it is said usually to kill the worm, a purgative should be taken both before and after the administration of the remedy. Its important constituent is *embelic acid*, which is found to possess the same properties as the drug itself. Embelic acid, the formula for which is $C_9H_{14}O_2$, occurs in orange-yellow scales, souble in alcohol, odorless and tasteless. It is given in doses of gr. iij.–vi. (0.2–0.4), to be both preceded and followed by castor oil. The fruit contains also resin, fat, tannin, and a small amount of an alkaloid, which has been called *christembine*. The powdered fruit is given in doses of from ʒi.–iv. (4.0–16.0) and the fluid extract in corresponding amount. Henry H. Rusby.

**Embolism.**—That form of metastasis in which free and movable insoluble substances are transported by the blood current and lodged in some part of the vascular system is known as embolism. The material transported is an embolus. The process may occur in lymph vessels (lymphogenous embolism), as well as in blood-vessels (hematogenous embolism). The latter is, however, the more common and important form, and embolism is usually understood to mean this when no special modifying designation is used.

The substances which may enter the vascular system and be carried in the blood stream as emboli are of the most varied character. They may be gaseous, liquid, or solid. The most common emboli are those composed of the products of coagulation of the blood and, unless specially designated, an embolus is usually understood to be derived from a thrombus. Tumor cells, living or dead tissue elements, animal or vegetable parasites, parenchymatous cells, placental cells, fat, pigment, masses of calcification, air, and various extrinsic substances may also gain entrance into the blood stream and form emboli.

The lodgment and impaction of the embolus in the vessel is due to the fact that on account of either its size or its physical properties the material transported is caught upon an obstruction in the vessel or cannot pass its lumen, and so remains either partially or wholly blocking it. Metastasis in the direction of the normal current is known as direct embolism, in the opposite direction as retrograde. The transportation of emboli from the veins into the systemic arteries without passing through the pulmonary circulation is designated crossed or paradoxical embolism. This may occur in case of a patent foramen ovale or a persistent ductus Botalli.

The importance of the embolism depends upon the nature of the embolus, its size, and the anatomical location and relation of the obstructed vessel. Emboli containing tumor cells or infective agents, as bacteria, are the most injurious (septic emboli); those consisting of dead tissues or substances incapable of growth act only mechanically in obstructing the circulation (bland or aseptic emboli). Hard or sharp-pointed substances may injure the vessel wall and lead to the formation of an aneurysm. Toxic or infective emboli may weaken the wall of the vessel and also produce aneurysms. Large emboli may seriously interfere with the nutrition of the part supplied by the obstructed vessel. Embolism of small arterioles or capillaries may produce

a very slight disturbance of nutrition or none at all. If the embolus does not completely occlude the vessel no serious circulatory disturbance may be caused, but the complete closure of the vessel usually follows from the formation of an induced or secondary thrombus. If the obstructed vessel has abundant collateral anastomoses beyond the point of obstruction no disturbance of nutrition of any consequence may occur; but if the obstructed vessel is a terminal artery poorly provided with collaterals, degeneration or necrosis of the part supplied by it will result from an insufficient supply of nutrition (anemic and hemorrhagic infarction).

*Direct Embolism.*—Embolism in the direction of the normal blood current is of most frequent occurrence. The substance forming the embolus is carried along by the blood stream until it is caught by some obstruction or swept into a channel so narrow as to prevent its farther passage. It follows, therefore, that direct embolism can occur only in the pulmonary and systemic arteries, heart, and portal vein. Emboli found in the right side of the heart or pulmonary arteries have their origin in the systemic veins; those found in the systemic arteries arise in the pulmonary veins, left heart or large arterial trunks. Portal vein emboli take their origin from thrombi either in the main trunk or in its contributing branches. The course and site of lodgment of the embolus is determined by the size, form, weight, and character of the material composing it, as well as by the force and volume of the blood stream, the size of the blood-vessels, the angle at which they are given off, the position of the body, etc. Consequently emboli arising in the systemic veins or right heart are more frequently carried into the pulmonary arteries supplying the lower lobes of the lungs, and more frequently into those of the right lower lobe than into those of the left. Larger emboli may block the main trunk of the pulmonary artery or even the conus arteriosus. Masses large enough to fill the right ventricle may be formed by the rolling together and balling of long stringy thrombi coming from the peripheral veins or from the right auricle. Emboli from the left heart more frequently pass into the thoracic aorta than into the carotid or subclavian arteries. The left carotid arising from the highest point of the aortic arch is more likely to receive emboli than the right carotid. In such a case the most frequent lodging-place of the embolus is at the division of the carotid or in the left middle cerebral artery. Very small particles will lodge in the straight perforating vessels supplying the basal ganglia. Likewise the left common iliac artery, being more directly in the line of the current in the abdominal aorta, receives emboli more often than the right iliac. The renal, splenic, and superior mesenteric arteries are especially predisposed to embolism. Since the conditions in the systemic veins are much more favorable for thrombosis, embolism of the pulmonary arteries is much more common than of the systemic arteries. Of the latter the small branches in the lower extremities are most likely to receive emboli, but in the great majority of cases this event is not diagnosed clinically, inasmuch as the symptoms produced are of much less importance than those caused by embolism of the renal arteries, splenic, etc.

If the embolus completely closes the lumen of the obstructed vessel, it is styled an obturating embolus. Spherical emboli are most likely to do this, but an elongated portion of a thrombus may be folded several times upon itself and pushed into a vessel several times its own diameter, completely obturating the lumen. This happens very often in the case of long pieces of thrombi washed out of the femoral veins and in this manner blocking up the largest branches of the pulmonary artery. Similarly, irregular thrombi of soft consistence may be pushed into a vessel so as completely to fill it. If the embolus is hard and firm there may still be some space left for the blood to flow, but this is usually soon closed by secondary thrombosis. Cylindrical, or elongated, flat irregular emboli may be caught at an arterial bifurcation and be pushed partly into both branches, either wholly or partly blocking them (straddling or riding embolus). Large soft thrombi may break up and the resulting emboli may fill a large number of small branches. Emboli arising in the systemic veins small enough to pass the pulmonary capillaries may lodge in the cerebral or renal capillaries.

*Retrograde Embolism.*—A retrograde transportation and impaction of an embolus is more likely to occur in the lymph stream than in the blood, and plays a very important part in the lymphogenous metastasis of tumors. Under especial conditions retrograde embolism may occur also in the veins, usually in the large veins near the heart. The cause of the retrograde transportation may lie either in a reflux flow from the heart and great veins into the hepatic veins or the veins of the neck, head, or arms; or in case of extreme venous stasis an embolus may be gradually pushed backward in the vein by abnormal venous pulse waves proceeding from the heart. This event is most likely to occur in dilatation of the right heart with tricuspid insufficiency. Any condition which increases the pressure in the veins near the heart favors also a retrograde embolism—decreased negative pressure in the thorax, disturbances of respiration, prolonged and difficult expiration, cardiac insufficiency, etc. Severe respiratory disturbances (coughing, forced breathing) may cause a positive pressure in the thoracic cavity and a backward flow in the veins. If the venous valves remain adequate the embolus may be caught on them, but in the extreme distention of the vessels they become insufficient and allow the embolus to pass. Retrograde metastasis has been observed in the hepatic, cerebral, mesenteric, renal, pulmonary, axillary, and coronary veins, pampiniform plexus, and dural sinuses. It has been most frequently observed in the case of tumor metastasis, but retrograde transportation of liver cells and infective emboli has also been reported. In the case of non-infective thrombotic material it would be very difficult to establish a diagnosis of retrograde embolism.

*Paradoxical Embolism.*—The passage of emboli through an open foramen ovale or persistent ductus Botalli without passing through the pulmonary circulation is known as paradoxical or crossed embolism. An opening in the foramen ovale in the shape of a narrow oblique slit is found in a relatively large number of autopsies. Under conditions of disturbed pulmonary circulation in which the pressure in the right auricle becomes greater than that in the left, the slit in the foramen is widened and its membranous edges are bulged into the left auricle. The opening may be so enlarged that not only small emboli may pass through it, but thrombi arising in the right side of the heart may extend through it into the left auricle. Masses of tumor cells and liver cells, the latter in cases of traumatic laceration of that organ, have been found obstructing the opening. Aside from such autopsic evidence the diagnosis of crossed embolism is impossible. The metastasis of certain large-celled tumors is best explained by the assumption of paradoxical embolism, but the possibility of even large tumor cells passing through the pulmonary capillaries without setting up lung secondaries must be borne in mind.

Varieties of Emboli.—*Bland Emboli.*—These are composed for the greater part of thrombotic material which does not contain toxic or infective agents; but no sharp line can be drawn between them and septic emboli, inasmuch as emboli may contain pathogenetic organisms and yet not give rise to septic processes, because of the action of the protective forces of the body inhibiting their growth. The practical criterion

is not the absence or presence of microorganisms in the embolus but the effect of the latter upon the vessel wall at the point of lodgment. A bland embolus is accordingly one whose effects are purely mechanical. Besides thrombotic material, pigment granules, dead cellular elements, fat, masses of calcification, extrinsic substances such as carbon or metal dust, etc., may produce only mechanical effects.

*Simple Blood-clot Emboli.*—The embolism of blood-clots is perhaps the most common form, and is the chief danger attending thrombosis (*thromboembolism*). In about fifty per cent. of all cases of thrombosis death takes place directly from embolism or as the result of embolic infarction or embolic pneumonia. The chief source of such emboli are the thrombi in the femoral or iliac veins following gynecological or surgical operations in the pelvis, or resulting from traumatic injuries to these vessels. Similar emboli may arise from thrombose varicose veins in the legs. Emboli arising from such sources lodge usually in the pulmonary vessels. If large enough to block a main trunk death may be instantaneous, or follow quickly after symptoms of dyspnea, great anxiety, cyanosis and convulsions; if smaller vessels are blocked a metastatic pneumonia usually develops. Very large emboli may lodge in the right heart. In the arterial system simple blood-clot emboli may arise from cardiac thrombi, endocardial vegetations, aneurysmal clots, aortic thrombi, etc. It is often difficult at autopsy to distinguish between an embolus and a thrombus. The former is usually not attached to the wall, and its general appearance may indicate that it was not formed *in situ*. When a secondary or induced thrombus has been formed upon the embolus it may be impossible at times to decide. The thrombus in such cases will always be a red one, however, so that a white or mixed portion of the clot may be safely regarded as a primary embolus.

*Infective Emboli.*—Because of their frequent occurrence and the serious conditions resulting from them infective emboli containing pathogenetic microorganisms are of very great pathological importance. In addition to the purely mechanical effects produced by them they show at the point of lodgment the characteristic effects of the bacteria which they contain. These effects are chemical in nature, the result of the specific products of the organism, and are characterized by degeneration or necrosis of the vessel wall, hemorrhages, inflammation, suppuration, gangrene, etc. As a result of the weakening of the wall through the injury or destruction of its inner coat an aneurysm may be formed (aneurysma mycotico-embolicum). Such embolic aneurysms occur frequently as the result of embolism of peripheral arteries in chronic ulcerative endocarditis. The metastasis of emboli containing pyogenetic organisms gives rise to the condition known as pyemia. The primary focus of the embolism is usually an infective venous thrombus formed at the point of entrance of the bacteria, which may be in any part of the body. From this thrombus emboli may arise and convey the bacteria to other parts of the vascular system, where having lodged they may multiply and produce poisons which exert their characteristic effects upon the vessel wall and surrounding tissues. From these secondary foci other emboli may be given off and the process indefinitely repeated. Infected thrombi in the femoral and iliac veins after gynecologic and surgical operations in the pelvis, also in infected varicose veins of the legs, are the chief sources of infective emboli lodging in the pulmonary vessels. In the arterial system the chief source of infective thrombi is found in malignant endocarditis of the mitral valves.

There may be no evident primary focus and the secondary lesions may form the only features of the disease; or, as in the case of malignant endocarditis, infective thrombi may form upon the valves of the heart and give origin to infective emboli, though the primary entrance of the bacteria into the vascular system cannot be discovered (cryptogenic infection). Embolism of bacteria alone from the primary focus, either singly or in masses, may occur without the formation of an infective thrombus at this point. These may become attached to the vessel wall, multiply, and set up their characteristic changes. In this manner bacteria arising in infective thrombi in the systemic veins may pass the lung capillaries and produce their effects in the systemic arteries or capillaries. As mentioned above, not all emboli containing pathogenetic bacteria give rise to secondary lesions at the point of lodgment. This may be explained by an increase in the vital resistance of the body or a diminished virulence of the bacteria due to conditions arising either in them or in the body. Nevertheless an infective embolic postoperative pneumonia is so common after pelvic operations that it is one of the chief fears of the gynecologist.

*Tumor-cell Emboli.*—Very rarely benign tumors may extend into blood-vessels and give rise to emboli which may develop into secondary growths of the same nature as the primary. In the metastasis of malignant tumors embolism plays a much more important rôle, as it is the chief factor of their spread through the body. Both carcinoma and sarcoma very frequently break into blood-vessels, loosened tumor cells are carried away in the blood stream, and from the emboli thus produced secondary growths arise. The development of a metastasis does not invariably follow the embolism of tumor cells. Encapsulation and resorption of the tumor-cell embolus may be accomplished by means of granulation tissue and foreign-body giant cells. It may be emphasized here that this embolism is always one of tumor cells and not of parasites which may cause the formation of such cells. The structure of sarcoma particularly favors hematogenous metastasis, inasmuch as the cells of a sarcoma not infrequently form the wall of the blood-vessels of the tumor, or are separated from the blood stream by an endothelial layer only. On the other hand, the spread of carcinoma into the lymph spaces favors lymphogenous metastasis, and in general it may be said that sarcoma and carcinoma are characterized respectively by hematogenous and by lymphogenous metastasis. Large masses of tumor cells coming from the systemic veins may block the orifices of the right heart or the pulmonary artery and cause sudden death. As a rule, however, the mechanical effects of emboli composed of tumor cells are unimportant when compared to the significance of the tumor metastasis. More frequently the secondary growths of malignant tumors arise from capillary emboli rather than from those of large size. Tumor cells of small size may pass the pulmonary capillaries without lodgment and give rise to secondary growths in the systemic capillaries. Both the retrograde and the paradoxical varieties of embolism of tumor cells have been observed.

*Emboli of Animal Parasites.*—The *Filaria sanguinis*, *Bilharzia hæmatobia*, and the *Plasmodium malariæ* may be found in the blood of the human body, and under certain conditions may block the capillaries or smaller arterioles. Echinococcus cysts in the heart wall may rupture into the blood stream and give rise to general metastasis. Echinococcus cysts may also enter the hepatic vein and lodge in the lungs. Cysticerci may also enter the blood stream and lodge in the eye or brain. The embryos of trichina pass from the intestine to the muscles through the lymph and blood, and the amebæ found in the intestine may reach the liver by way of the portal vein.

*Fat Embolism.*—This is probably a very common form of embolism, but in the majority of cases it is of little pathological significance. Nevertheless, it has the greatest practical importance next to throm-

boembolism. Not infrequently it is fatal, in conditions when so much fat is set free into the circulation as to block up many capillaries and small arteries; or a moderate fat embolism may aid in causing death in cases of shock, cachexia, anemia, etc. The source of the fat is usually the fatty bone marrow, but fat may enter the circulation as the result of injury to any tissue or organ of the body which contains fat. Amputations, fractures, crushing, orthopedic manipulations, etc., of bones containing fatty marrow are the most common causes, but even slight concussion of the bones may set free some fat into the blood-vessels. Congestion or inflammation of the marrow may also lead to fat embolism. Injury to adipose tissue in breast amputations, in laparotomy, during child-birth, in laceration or necrosis of fatty liver, destruction of brain tissue, in fatty degeneration of sclerotic plaques, convulsions, as in eclampsia, etc., may also cause the entrance of fat into the circulation. Fatty embolism has also been observed in the lipemia of diabetes, and has been supposed to be a cause of the dyspnea and coma in this disease.

The fat droplets floating in the blood stream collect for the greater part in the lung capillaries, and in severe cases the majority of these vessels may be found greatly distended and filled with plugs of oil. The capillaries of the brain, kidneys, and heart suffer next in proportion. Fatty embolism of the small arteries of the gastric mucosa may give rise to hemorrhagic erosions. Layers of fat may occasionally be present in the postmortem clots found in the heart and great veins. The results of fatty embolism are purely mechanical. In a moderate degree the fat may be disposed of by saponification, emulsion, phagocytosis, etc. Death takes place as the result of the disturbance of the respiratory function (edema of the lungs), or from the cerebral or cardiac lesion.

*Cellular Embolism.*—Pulmonary embolism of the giant cells of the bone marrow is of very frequent occurrence, being found in many toxic and infective conditions, pernicious anemia, splenic anemia, leukemia, congestion and inflammation of the bone marrow, injury to the bones, etc. It occurs to the greatest extent in puerperal eclampsia, but is also commonly found in the lungs of women dying in the puerperium of diseases other than eclampsia. The significance of the process is not yet known; within a limited degree it may be physiological, or it may occur just before death as a pre-agonal phenomenon. In the acute infections the existing hyperemia of the bone marrow may be the underlying cause of the metastasis. Injury to the bones may cause a metastasis not only of the fat and giant cells of the marrow but also of portions of marrow tissue and bony fragments. The giant cells appear in the lung capillaries as deeply staining masses of chromatin having a very irregular knobbed shape, rarely multinuclear. As a rule the cells are crowded so tightly into the capillaries that no cell protoplasm can be made out, but in the cells found in the small arterioles the protoplasm is usually intact. In puerperal eclampsia the number of giant-cell emboli may be as great as from six to eight in every low-power field. This variety of embolism is also found in association with other forms of cellular embolism—*e.g.* that of liver cells, placental cells, etc. Giant cells resembling those of the marrow may originate in the hemolymph glands in fatal cases of anemia, and it is possible that these may also give rise to pulmonary embolism.

Giant cells arising from the syncytium of the chorionic villi have also been found in the pulmonary capillaries in cases of puerperal eclampsia, hydatid mole, etc. According to Schmorl, this form of embolism plays an important rôle in the etiology of eclampsia; but this is probably not the case, as it is not constantly found in this disease and may be present in the lungs of puerperal women not suffering from eclampsic symptoms. Further, since the differential diagnosis of multinuclear bone-marrow cells and syncytial cells is practically impossible, it is probable that many of the emboli found in the pulmonary capillaries and thought to be syncytial cells were in reality bone-marrow cells. In case of hydatid moles portions of syncytial buds or villi may break into the uterine sinuses and be carried to the lungs, but this process must be regarded as being of the nature of a tumor metastasis.

After traumatic laceration of the liver, large portions of liver tissue have been found in the pulmonary arteries. Small pulmonary emboli of liver cells may occur after hemorrhage and necrosis of the liver. Paradoxical embolism of liver cells has also been observed, and portions of liver tissue have been found blocking the foramen ovale. In connection with liver-cell embolism pulmonary emboli of bone-marrow giant cells are usually present.

Splenic cells, sometimes containing malarial parasites and pigment, red blood cells, or blood pigment, may be found under certain conditions in the liver capillaries. Portions of endothelium, bits of the heart valves, etc., may also be loosened into the blood stream and form emboli in the capillaries of various organs: brain, spleen, kidneys, etc.

As a rule, the practical significance of cellular embolism is not great; the cells degenerate, become necrotic and are resorbed. Secondary thrombosis may however take place upon the dead cells.

*Air Embolism.*—Air may enter the circulation through wounds or surgical operations about the neck, upper part of thorax, shoulders and head, in which conditions the air is sucked into open veins by means of respiratory aspiration. Air may also enter the circulation through the uterine veins after separation of the placenta in abortion, placenta previa, uterine injections, etc.; or open veins in ulcers of the stomach and intestines may be the point of entrance. Gaseous embolism may be produced by infection with gas-producing bacilli (*B. aërogenes capsulatus*). The cause of death in caisson disease has been thought to be emboli of nitrogen which has been absorbed by the blood under high atmospheric pressure and suddenly released on return to normal atmospheric conditions. It is probable that many of the cases reported as air embolism, especially those in which the air has been supposed to enter the uterine or stomach veins, have been in reality cases of gaseous embolism due to infection with the Bacillus aërogenes capsulatus. Death results from paralysis of the right heart and stasis of the pulmonary circulation. The elastic air collects in the right ventricle and is compressed there, mingled with the blood to form a stiff frothy mass, sometimes resembling a stiff-beaten white of egg. The heart cannot force this on through the lungs, the right ventricle becomes dilated, and cardiac paralysis results.

Effects of Embolism.—The metastasis of dead or inert substances incapable of growth produces chiefly mechanical effects, inasmuch as their chemical properties are not usually such as to cause further alterations in the vessel walls or its neighborhood. Of the purely mechanical effects the most important is the obstruction of an artery by an embolus. If the embolized vessel has abundant anastomoses, as is the case with the arteries of the voluntary muscles, skin, bone, uterus, thyroid, etc., there may be no appreciable disturbance of the circulation; but if the obstructed vessel has few anastomoses and a collateral circulation is not quickly established, the tissues supplied by the occluded artery will quickly degenerate or necrose as the result of the anemia. The area of anemic necrosis produced by the occlusion of an artery by either thrombosis or embolism is known as an infarct. Two varieties of infarcts are distinguished; anemic or white, and the hemorrhagic or red infarct. The former occurs as the result of the

occlusion of terminal arteries in the kidneys, spleen, heart, brain, and rarely in the liver. The hemorrhagic infarct occurs regularly as the result of the obstruction of the terminal branches of the pulmonary and superior mesenteric arteries. It differs from the anemic only in that into the necrosed area there is an infiltration of blood. It is therefore a hemorrhagic-anemic necrosis. The hemorrhage into the necrosed tissue takes place by diapedesis from the injured walls of the vessels lying within or at the border of the infarcted area. These become partly filled with blood from collateral capillaries and arterioles, and the vessel walls, weakened by disturbance of nutrition from the lack of their accustomed blood supply, permit of hemorrhage by diapedesis. The low tissue-resistance in the lung and mesentery and submucosa of the intestines also favors hemorrhage. Surrounding the anemic infarcts of the spleen, heart, kidneys, etc., there is always a narrow zone of congestion and hemorrhagic infarction which is visible in the fresh specimen as a red line surrounding the gray or yellowish dead anemic area. This may be explained as being due partly to collateral congestion and partly to hemorrhage from the small anastomosing vessels at the border of the infarct, whose walls also suffer disturbance of nutrition from the anemia or stasis, and permit the escape of blood by diapedesis. In cases of extreme venous congestion this border-line of hemorrhage may be greatly increased in size and an anemic infarct may for the greater part or wholly become hemorrhagic. Thrombosis in the veins also favors the production of hemorrhagic infarction. It is probable that under normal conditions of the circulation occlusion of a terminal branch of etiher the pulmonary or the mesenteric arteries will produce no infarction owing to the rich collateral anastomosis. Under conditions in which the circulation in these vessels is already impaired obstruction of their terminal branches will produce a hemorrhagic infarct. The fact that infarcts of the lung and intestines are invariably hemorrhagic has not yet been satisfactorily explained, but it is supposed that the rich anastomoses of the pulmonary and superior mesenteric arteries lead, through the establishment of a collateral flow, to the refilling of the vessels of the infarcted area, and that the walls of these vessels having been damaged by the anemia permit of diapedesis.

Embolism of the coronary arteries, the valvular orifices, the pulmonary artery or its main branches, or the bulbar arteries may cause immediate death. Fat embolism of the cerebral, pulmonary, or renal capillaries may be so extensive as to cause death by obstruction of the circulation and disturbances of nutrition. Less severe cases may cause coma, dyspnea, etc., while moderate degrees may produce no symptoms at all. Likewise air embolism in small amount may produce no effect. Larger amounts of air may collect in the right heart and pulmonary artery in a frothy mass which the heart is unable to force through the pulmonary capillaries, death resulting from paralysis of the heart. In caisson disease death may follow the embolism of bubbles of nitrogen which have been suddenly liberated in the blood by the too sudden reduction of the high atmospheric pressure under which it had been absorbed. The effects of embolism of cellular elements, animal parasites, etc., are purely mechanical. Pulmonary embolism of placental cells has been thought to be the cause of eclamptic convulsions. Tumor cells not only act mechanically but give rise to secondary growths as well. Sharp-pointed masses of calcification, etc., not only cause obstruction of the circulation but may so injure the vessel wall as to lead to the formation of an aneurysm.

Toxic and infective emboli, in addition to their purely mechanical effects, produce changes in the vessel wall and its neighborhood due to the action of the poisons which they contain or which are produced by the bacteria contained within them. Degeneration, necrosis, and inflammation of the vessel at the point of obstruction may lead to a widespread purulent arteritis, formation of abscesses, etc., or as a result of the weakening of the wall aneurysms may be produced.

*Sequelæ.*—In the case of embolism of thrombotic material organization, simple and purulent softening, or calcification of the embolus may take place. The sequelæ of infarction are essentially the same as those of necrosis in general: organization, encapsulation, cyst formation, calcification, abscess, gangrene, etc. Emboli of liver cells quickly necrose, the dying cells forming centers of coagulation and thrombus formation. Bone marrow and placental giant cells undergo a slow necrobiosis, and may also give rise to thrombosis. Small bits of dead tissue, pigment granules, and bacteria may be removed by phagocytes. Fat in small amount is saponified or emulsified, or disposed of by phagocytosis. A large part of it is also excreted through the urine. Small amounts of air may be absorbed.

Symptoms.—The general symptoms of non-infective embolism depend upon the anatomical position and relations of the occluded vessel, the specific function of the part supplied by it, and the degree of anemia produced by the obstruction. The passage of the embolus through the vessels or heart causes no definite symptoms. Pain may follow the impaction of an embolus in an artery, particularly in the abdominal aorta, mesenteric, iliac, and femoral arteries. At times it is very severe, having the character of that of a painful blow. It is probably due to the irritation of sensory nerves in the vessel wall caused by the sudden impaction and distention. Pain may follow the embolism as a result of local anemia, inflammation, and the various sequelæ of infarction. In rare cases a chill or fever may accompany the impaction of non-infective emboli. Fever, however, usually follows embolism as one of the accompanying phenomena of secondary inflammation, sepsis, gangrene, etc. Embolism of vessels supplying visible parts of the body may be manifested by signs of local anemia, gangrene, etc. Infarction of the lungs, kidneys, and intestines may be shown by hemorrhage from these organs. Infarction of any organ will lead to disturbance of its function. In the case of infective emboli, besides the symptoms due to the mechanical obstruction of the circulation, those of local and general infection are present: chills, fever, etc. These are usually of such great importance as completely to cast into the background the symptoms of local anemia or infarction.

The order of frequency of arterial embolism is given by Welch as follows: pulmonary, renal, splenic, cerebral, iliac and arteries of lower extremities, axillary and arteries of upper extremities, celiac axis with hepatic and gastric branches, central artery of the retina, superior mesenteric, inferior mesenteric, abdominal aorta, and coronary arteries. This order is based not so much upon the actual occurrence of emboli as upon the symptoms of embolism. It is very probable that embolism of the small arteries of the lower extremities would come next to the pulmonary in the order of frequency, but the signs or symptoms attending this event may be so unimportant as to be overlooked.

*Pulmonary Embolism.*—Embolism of the main trunk or both of the main branches of the pulmonary artery is usually followed by sudden death from syncope. In other cases there may be a sudden attack of intense precordial pain and dyspnea followed quickly by death. In less extensive pulmonary embolism the chief symptoms may be intense dyspnea, cyanosis, great disturbance of heart action and respiration, sweating, chills, syncope, convulsions, coma, etc. Embolism of the smaller terminal branches may produce no symptoms, but very often hemor-

rhagic infarction is accompanied by chills, dyspnea, fever, pain in the side, pulmonary hemorrhage, etc. Infective emboli give rise to pyemic abscesses, purulent and fibrinous pneumonia, and the local and general symptoms arising from these conditions. Pulmonary edema and hemorrhage, associated with fat in the sputum, are the chief signs of fatty embolism of the pulmonary vessels.

*Renal Embolism.*—Large infarcts of the kidney may cause pain; small ones are unaccompanied by painful sensations. Hematuria is the most important sign of renal infarction. Infective emboli cause pyemic abscesses. These are manifested by severe constitutional symptoms of intoxication, pyuria, etc.

*Splenic Embolism.*—Infarction of the spleen may occur without signs or symptoms, but frequently there are sudden pain in the splenic region, chills and fever, splenic enlargement, perisplenitic friction, etc. Infective emboli may cause splenic abscess with symptoms of pyemia.

*Cerebral Embolism.*—The left middle cerebral is most commonly involved. Sudden hemiplegia and aphasia are the chief symptoms. Embolism of the vertebral or basilar artery produces symptoms of acute bulbar paralysis.

*Mesenteric Embolism.*—Infarction of the intestines is usually manifested by sudden attacks of severe colicky pain, abdominal tenderness, bloody or fecal vomiting, blood in the stools, gangrenous odor of stools, sweating, subnormal temperature, and collapse. Death usually occurs within a very short time. Very rarely the symptoms are less pronounced and of such vague character as to make diagnosis impossible. The condition may very much resemble that of intestinal obstruction. Embolism of the smaller branches of the intestinal arteries gives rise to the formation of intestinal ulcers.

*Aortic Embolism.*—The occlusion of the thoracic aorta by embolism is of very rare occurrence. It may be caused by the dislodgment of large thrombi in the heart or in aortic aneurysms above the point of embolism. Death is instantaneous or occurs within a very short time. Embolism of the abdominal aorta is not of such rare occurrence. In the majority of cases the embolus arises from a heart thrombus. The symptoms may develop suddenly or the onset may be gradual. Pain in both legs, often extreme, is usually present; with this there is associated paralysis, absence of femoral pulsation, and ascending gangrene. Death may occur within a few hours or be delayed for months, in the latter case the result of slowly progressive gangrene or sepsis. Embolism of the iliacs, or of the femoral or popliteal arteries is manifested by similar symptoms varying in degree with the size of the vessel occluded and the location of the embolus.

*Coronary Embolism.*—Embolism of the larger branches of the coronary arteries causes sudden death, or an attack of extreme dyspnea and severe precordial pain which may be followed shortly by death. Embolism of the smaller branches may cause anemic infarction with symptoms of angina pectoris. As a result of the weakening of the heart wall by the infarction rupture of the heart into the pericardial sac may take place causing sudden death, or aneurysmal dilatation of the heart may be produced, leading to serious impairment of cardiac efficiency.

*Retinal Embolism.*—Sudden blindness is produced by the embolic occlusion of the central artery of the retina. Ophthalmoscopic examination reveals a condition of retinal infarction usually without the occurrence of hemorrhage. In embolism of the smaller retinal branches multiple hemorrhages usually occur with more or less pronounced disturbance of vision.

*Embolism of Spermatic Artery.*—Occlusion of the spermatic artery by embolism is said to have caused gangrene of the testis in a small number of cases.

Diagnosis.—Since the chief symptoms of embolism are of the same nature as those of thrombosis, the differential diagnosis of these two conditions is of main importance. The sudden development and severity of symptoms of arterial anemia are more characteristic of embolism than of thrombosis. Absolute dependence cannot, however, be placed upon this point, inasmuch as thrombi occasionally occlude with great rapidity, while on the other hand the symptoms of embolism may be slow of development owing to the fact that the embolus either does not entirely obturate the vessel which is later completely closed by secondary thrombosis, or the embolus may be so situated that the secondary thrombosis plays the chief part in the production of the anemia. After arterial embolism the establishment of the collateral circulation usually leads to a more decided improvement of symptoms than is commonly the case after thrombosis. Absolute reliance cannot be placed upon this factor, since occasionally after thrombosis very marked amelioration follows the development of the collateral circulation. The occurrence of arterial obstruction in young individuals or in adults showing no signs of arteriosclerosis, of embolism. If arteriosclerosis is present, the especially in cases of valvular lesions of the left side of the heart, points very strongly to the occurrence differential diagnosis between thrombosis and embolism becomes much more difficult.

The establishment of a source for emboli in the existence of a previously formed thrombus, cardiac disease, aneurysm, infected wound, etc., is the most reliable factor in the diagnosis of embolism. In pulmonary embolism the source may be sought in thrombi in the systemic veins or right heart. In embolism of the systemic arteries the chief source of the embolus is disease of the mitral or aortic valves. Thrombi in aortic aneurysms may also give rise to emboli. Infected wounds, abscesses, acute endocarditis, etc., form the sources of infective emboli. Abortion, separation of the placenta, uterine injections, pregnancy, etc., are conditions in which embolism may occur. Injury of the bones or fat-containing tissues gives rise to fatty embolism. The occurrence of pulmonary edema, or of coma with increase of temperature after fractures or orthopedic manipulations of bones should give rise to a suspicion of the occurrence of fatty embolism. The diagnosis can be made positively by the demonstration of the presence of fat in the sputum and urine. Though cases may occur in which the source cannot be found, and though the existence of a thrombus in one vessel does not exclude the occurrence of thrombosis in others, it is possible, in the majority of cases, to make a correct diagnosis of embolism whenever definite symptoms are present.

Treatment.—Prophylactic treatment may be of the greatest importance in the prevention of the detachment of an embolus from a thrombus. In the case of venous thrombosis of the lower extremities absolute rest of the affected limb, or better of the body as a whole, should be insisted upon, as a very large percentage of the cases of death from pulmonary embolism occur as the result of the patient's movements in walking, bathing, or going to stool. Walking should not be allowed for at least six weeks after venous thrombosis of the lower extremities. Massage or palpation of the affected vein, or even pressure upon it with a stethoscope, as well as all unnecessary movement and manipulation of the limb, should be avoided. Prophylactic measures may be instituted further against the formation of thrombi by stimulation of the heart's action, improvement of the general nutrition, prevention of extension of infection by surgical interference, etc. In the case of acute endocarditis, heart thrombus, aortic aneurysm, etc., absolute rest is also essential as a prophylactic

measure against embolism. Fatty embolism may be prevented by the avoidance of direct pressure upon atrophic bones during orthopedic manipulations, complete rest after fractures, draining of the wound, draining of the thoracic duct, etc.

After embolism has occurred the general indications are relief of pain, absolute rest, proper nourishment, cardiac stimulation, etc. In the treatment of fatty embolism transfusion with large quantities of saline is advised. The development of the collateral circulation should be brought about as soon as possible in order to avoid anemic necrosis. In case of embolism of accessible portions of the body this may be aided by the local application of heat. When infarction has taken place the general indications of treatment are along lines tending to promote absorption and organization of the dead tissues. In the case of gangrene of the lower extremities and intestinal infarction operation according to general surgical principles may be performed.

ALDRED SCOTT WARTHIN.

**Embryo, Pathology of the.**—The most important step in the existence of an individual is the beginning, the fertilization of the ovum by the spermatozoon. The quality of this initial combination determines to a most far-reaching extent the capabilities, tendencies, reactions and responses of the tissues and parts of the resulting organism. Even before modern studies had shown how consistently each cell of the offspring is composed of elements derived partly from maternal and partly from paternal sources, Huxley had cleverly expressed the situation by comparing the entire organism to a web, of which the warp is derived from the female and the woof from the male.

With this conception in view, we are impressed with the absolute necessity of a normal combination of germ cells in order to obtain a normal embryo. The tendencies possessed by the germ cells are considered the internal factors in development. The path of development depends, however, not alone upon these factors, but also upon the nature of the environment in which the egg develops, the external factors. The embryonic product is therefore the resultant of two groups of forces, the internal factors contained within the germ cells, and the external factors acting upon the developing embryo.

A normal embryo arises from the normal interaction of all the factors, while modifications or deviations from the norm in either the germ cells or the environment result in a marked or slight pathological condition, depending directly upon the extent of the deviation. A healthy, resistant germ cell may apparently successfully survive an unfavorable environment, while a defective germ may be more or less successful in a favorable environment, but in either case the developing individual suffers to some extent.

Malino found that 19.23 per cent. of the pregnancies of 2,000 patients ended in abortion, and in the lying-in hospital in Halle Franz has reported 15.4 per cent. abortions. These percentages would be greatly increased should one take into account the large numbers of embryos that are lost shortly after fertilization, or at the time for the first menses following conception. Such aborted products often pass out unnoticed, resembling in appearance small blood clots. It would not be unfair to claim that about one-fifth of all conceptions among civilized human beings terminate in abortions (these estimates do not consider intentional or criminal abortion).

We may thus view this situation as an antenatal disease which sweeps away one-fifth of the population before it is born; few, if any, postnatal diseases claim such a toll. The question of interest in the present consideration is whether the aborted embryos are pathological or normal, and whether the abortion is primarily due to the diseased condition of the embryo or to the environmental condition, the uterine wall, placenta, or embryonic membranes. A further question presents itself, whether the eighty per cent. which escape abortion and survive have not also suffered from a milder form of the same conditions which destroyed the less successful twenty per cent. After all, is not Ballantyne correct in the position he has taken and so strongly defended with the abundance of material presented, that almost all postnatal pathological conditions are really of antenatal origin? A surprisingly large area of fertile soil for disease is presented by congenital conditions. These structural weaknesses may pass unnoticed for the greater part of one's existence, and may then under a strain of disease or what not, result in the death of the individual. All change of function has at base a change or modification in structure—a perfect structure functions perfectly, but the arrest in development or modification in structure of one group of cells impairs function and produces disease. The pathology of the embryo, if consistently studied in minutest detail, would richly repay the labor, since many perplexing problems of postnatal pathology doubtless hide their secrets here.

At present, however, only the crudest beginning is made in studying the finer pathology of the embryo. Gross pathological conditions are abundantly recorded and described and, as I shall show below, many have been classified with some success. It is impossible to refer to the vast varieties of monstrous and abnormal forms which are included in the classifications and the reader interested in this phase of the subject should consult the splendid works by Schwalbe, "Die Morphologie d. Missbildungen des Menschen und der Thiere," three volumes; Ballantyne's "Antenatal Pathology," two volumes, richly suggestive with a most comprehensive consideration of literature; the monograph by Mall, "A Study of the Causes underlying the Origin of Human Monsters," Journal of Morphology, vol. xix., 1908; and the able and lucid chapter by the same author on "The Pathology of the Human Ovum," in the Manual of Human Embryology edited by Keibel and Mall.

The present discussion aims more particularly at a consideration of the causes of pathological embryos, and briefly examines the experimental production in lower vertebrates of forms similar to those monsters observed in man, with an attempt at their interpretation. By this method of attack the question of control develops itself, and the physician should become interested in these antenatal diseases of structure as truly as he is in the science of postnatal pathology. There may be, and doubtless is, much to be done in the regulation of development vastly beyond the crude supervision practised today upon the pregnant woman. This is a far more urgent and practical question than that phase of the Eugenics movement which advocates selective matings. The time is distant when one may prescribe for the patient the type of mate to be selected, but every fertile pair will gladly welcome a system of treatment prophylactic or otherwise, which will insure them stronger and more nearly perfect offspring.

FREQUENCY OF MONSTERS OR PATHOLOGICAL EMBRYOS.—The high percentages of abortion mentioned above probably do not all contain pathological embryos, neither do the eighty per cent. of successful pregnancies all result in normal fetuses. Mall has estimated that about seven per cent. of all uterine pregnancies give rise to pathological embryos, while ninety-six per cent. of tubal pregnancies result in the production of monsters. Of the seven per cent. of uterine monsters only about one in twelve reaches term and is recorded as a deformed child; the other eleven-twelfths are all aborted during the early weeks of gestation.

The pathological condition usually begins in the early embryo and may be pronounced; it is then passed on to the fetus as a gross abnormality. The modifications which arise later are not usually so extensive as those occurring during the early stages of development. Developmental defects and minor arrests are extremely numerous; scarcely anybody is entirely free from them; they are the end results of pathological conditions in the embryo and fetus. When these minor defects are taken into account, almost all developing individuals are material for pathological study. A great amount of investigation is still necessary in order thoroughly to define our conceptions of the normal.

Mall states that his records include 434 specimens, among which are 163 pathological ova and embryos of various stages. There are 151 normal and 138 pathological embryos of the first two months of pregnancy. The experience of several collectors shows that physicians have a tendency to send only the good specimens, and the number of pathological ova among early abortions may be considerably higher than indicated. His found that of embryos sent him by physicians only twenty-two per cent. were pathological, while in the specimens sent by midwives the pathological specimens rose to forty per cent. Mall states that after urging physicians to send all specimens and not selected ones, the pathological ova of the first two months of pregnancy have been about fifty per cent.

The accompanying table by Mall facilitates a ready comparison of his data arranged in chronological series with those recorded by His.

TOTAL NUMBER OF NORMAL AND PATHOLOGICAL OVA OF FIRST TWO MONTHS.

| | No. of normal. | No. of pathological. | Percentage of pathological. |
|---|---|---|---|
| His's collection from all sources. | 62 | 18 | 22 |
| His's collection, only specimens obtained from midwives. | 19 | 12 | 40 |
| Mall's collection, 1st series, (Nos. 1 to 126). | 61 | 28 | 32 |
| Mall's collection, 2d series, (Nos. 127 to 208) | 24 | 37 | 61 |
| Mall's collection, 3d series, (Nos. 209 to 379). | 52 | 65 | 56 |
| Mall's collection, whole number (Nos. 1 to 404). | 151 | 138 | 48 |

According to Mall, there are about twice as many pathological ova in abortions of the first month as are found in those of the second month.

Marchand states that 615 monsters were found among 81,187 births. From these figures, along with Williams' statistics regarding the frequency of abortions and the percentage of pathological ova found among 434 abortions, Mall makes the following statement: "Eighty out of one hundred pregnancies end in the birth of normal individuals; seven are aborted as pathological ova containing radical changes within them; and about one (0.6) produces a monster at term. The remaining twelve "normal" fetuses and embryos are by no means all normal, for we are constantly finding in them, especially the younger specimens, minor changes which must be viewed as forerunners of real monsters."

It must be kept in mind that if the minor defects were more often recognized and more thoroughly studied, the number of embryos classed as showing pathological conditions would greatly increase.

CLASSIFICATION OF PATHOLOGICAL EMBRYOS.—Panum was the first to classify pathological embryos in his experimental study of monsters in the hen's egg. His used this classification as a basis for arranging pathological human embryos. Two primary groups of monsters were recognized by Panum; those in which the entire embryo was involved, and those in which only a part of it was defective. In the first group were included flat forms in which the shape of the germinal area was only slightly changed; second, flat forms with red blood in which the embryo only was affected; third, cylindrical forms where the embryo had become abnormal later in its development, and finally amorphous forms.

There are also many cases in which the embryo itself is destroyed entirely. Giacomini has described a number of such instances and Mall has often observed them, though His failed to recognize such a class. I have seen eight human chorionic vesicles which failed to contain any trace of the embryo, and in studying a large number of monster fish embryos several eggs have been observed with well developed yolk sacs and vitelline vessels, while the embryo was entirely absent; the same condition has been seen in the hen's egg. Panum long ago recorded hens' eggs in which the area vasculosa gave rise to blood although the embryo was entirely destroyed. In a very few cases I have observed fish eggs in which a pulsating heart was present on the yolk sac and blood flowing in the vitelline vessels, while no other embryonic structures were apparent. Gudernatsch has made similar observations.

Mall gives his classification of pathological embryos in "the form of a table in which the data are arranged with those of His, giving the number and percentage of specimens under each heading." The percentages are closely similar in the two collections. Mall compares his vesicular forms with His's nodular forms, since they are doubtless the same in most cases. While His never observed an ovum without an embryo, twenty-eight per cent. of Mall's specimens are of that type and the failure of His to observe such forms was doubtless due to the fact that no sections of his nodular types were cut.

| Classification. | His. | | Mall. | |
|---|---|---|---|---|
| | Number. | Per cent. | Number | Per cent |
| Ova without amnion or embryo | | | 29 | |
| Ova with amnion but without embryo. | | | 15 | |
| Vesicular (nodular) forms | 5 | | 19 | |
| Embryos 2–2.5 mm. long | 9 | 53.4 | 4 | 46.6 |
| Embryos 2.5–4.5 mm. long | 10 | | 18 | |
| Embryos 5–8 mm. long | 11 | 24.3 | 21 | 23.9 |
| Embryos 9–14 mm. long | 12 | 22.3 | 26 | 29.5 |

In the next table is shown Mall's arrangement of his collection in a somewhat different way, and the condition of the chorion in the several cases is indicated; the significance of this will be considered later.

Regarding his Group IV. Mall states: "The embryo is present in this group and is more or less degenerated. In case it is much degenerated it may produce a nodular embryo of His or an amorphous embryo of Panum. Usually after the fifth week it is quite easy to recognize the stage in which the embryo became pathological. The younger ones correspond with His's abortive, atrophic, or degenerated forms, the older ones often with his cylindrical forms. I have found it more convenient to arrange them in weeks according to the age of the embryo at the time the pathological process began."

The above tables and classification consider the embryo or ovum as a whole without reference to the special variety of defect. A consideration of the

known modifications and deformities of the various parts and organs of the embryo could only be taken up in volumes devoted to the subject. In the case of gross defects of the central nervous system hundreds of types could be arranged. The eyes lend themselves to almost every conceivable arrangement and defect. A few of these conditions will be mentioned in considering certain experiments aiming toward an explanation of the cause of abnormalities. If the reader is particularly interested in the varieties of defects exhibited by embryos and fetuses, the works of Schwalbe and Ballantyne referred to above should be consulted.

Distribution of 159 Pathological Ova in a Collection of 434 Specimens, Giving also the Condition of the Chorion.

| | C R length in mm. | Number. | Per cent. | Condition of chorion | | |
|---|---|---|---|---|---|---|
| | | | | Normal. | Pathological | No record |
| I. Vesicular forms | .... | 19 | 12.0 | 6 | 11 | 2 |
| II. Ova with neither amnion nor embryo. | .... | 29 | 18.0 | 6 | 22 | 1 |
| III. Ova with amnion but without embryo. | .... | 15 | 10.0 | 3 | 11 | 1 |
| IV. Embryos of the 4th week.... | 2½ | 4 | 3.0 | 0 | 3 | 1 |
| Embryos of the 5th week.... | 5½ | 18 | 11.0 | 1 | 11 | 6 |
| Embryos of the 5½ week..... | 8 | 21 | 13.0 | 0 | 15 | 6 |
| Embryos of the 6th week.... | 11 | 13 | 8.0 | 0 | 10 | 3 |
| Embryos of the 7th week.... | 17 | 27 | 17.0 | 1 | 23 | 3 |
| Embryos of the 8th week.... | 25 | 10 | 6.0 | 2 | 4 | 4 |
| Embryos of the 9th week.... | 32 | 2 | 1.4 | 0 | 2 | 0 |
| Embryos of the 10th week... | 43 | 1 | 0.6 | 0 | 1 | 0 |
| Total..... | .... | 159 | 100.0 | 19 | 113 | 27 |

Causes of Pathological Conditions in the Embryo.—From the time of the ancients various speculations have been advanced to account for the occurrence of abnormal forms. Many superstitions and religious ideas were involved; some tribes regarded such deformed conditions as curses while others considered monsters to be sacred individuals and their idols and images of their gods were modeled after many grotesque forms. Others held monsters to be the result of cohabitation with lower animals, while the moon was also thought to exert a causal influence. All of these ideas have long ago disappeared, though one only a little less fanciful still survives and is actually believed by many practitioners of medicine. This is the idea that maternal impressions may affect or modify the developing fetus in characteristic ways. Such an idea is entirely without foundation, strictly speaking, yet everyone will admit that a serious shock to the maternal nervous system may derange normal function and nutrition to such an extent as to affect secondarily the nutrition and vigor of the developing embryo. This latter fact is not to be construed in favor of the absurd notions that the child may later resemble the object of the mother's fright, having the visage of a dog or the appearance of a wild boar, in case the mother had been frightened by such animals.

The developing embryo, as before stated, is the resultant of two sets of forces, the internal factors contained within the germ cells from which it arose, and the external factors or the environmental condition in which it develops. All pathological conditions in development are therefore due to a defective germ cell or to development in an unfavorable environment, or to both of these causes. This is the modern conception of the etiology of pathological embryos.

*Germinal Influences.*—The pathological conditions are in some cases due to the fact that the embryo has arisen from a combination in which either the egg or spermatozoön, or both, were defective. The embryos may exhibit in different cases either slight or pronounced defects, and these may be early or late in making their appearance.

The germ cells of an individual may be naturally weak and defective, or may be artificially rendered so. In the first case there may be a familial disease or weakness causing the production of defective embryos through several generations. In the second place, a healthy individual with vigorous germ cells may be so treated or poisoned as to render the germ cells, either ova or spermatozoa, incapable of giving rise to a normal combination so that a pathological embryo results. Constantine Paul long ago observed that the offspring from men working in lead were almost all pathological, even though their wives had previously produced normal children and had not been subjected to the poison. It is generally believed that the children of a drunken father are often degenerates; this may be due either to the effects of the alcoholic poisoning or to the previous degenerate condition of the tissues and germ cells of the individual. The cause of the injured spermatozoon is immaterial, as in either case the abnormal male germ cell exerts a disease-producing influence on the developing individual even though it arose from a normal egg and developed within a healthy mother.

I have produced experimental evidence with mammals to show that the germ cells may be injured by poisoning the parental body, and such germ cells give rise to pathological embryos and offspring. Guinea pigs have been put into a chronic alcoholic state by being allowed to inhale the fumes of alcohol to almost the point of intoxication six times per week. The following table shows the results of mating such individuals in various combinations. The table gives the results after the experiment had run for two and one-half years.

Condition of the Offspring from Guinea Pigs Treated with Alcohol.

| Condition of the animals. | Number of matings. | Negative result or early abortion | Still-born litters. | Number still-born. | Living litters. | Young dying soon after birth. | Surviving young. |
|---|---|---|---|---|---|---|---|
| Alcoholic male.... × Normal female.... | 53 | 22 | 7 | 13 | 24 | 20 | 31 |
| Normal male..... × Alcoholic female.. | 14 | 2 | 3 | 9 | 9 | 9 | 10 |
| Alcoholic male.... × Alcoholic female.. | 27 | 14 | 3 | 6 | 10 | 5 | 9 |
| Summary..... | 94 | 38 | 13 | 28 | 43 | 34 | 50 |
| Normal male..... × Normal female.... | 33 | 0 | 1 | 4 | 32 | 4 | 56 |
| Second generation × Normal..... | 2 | 0 | 0 | 0 | 2 | 0 | 3 |
| Second generation × Alcoholic..... | 2 | 0 | 2 | 5 | 0 | 0 | 0 |
| Second generation × Second generation | 13 | 4 | 0 | 0 | 9 | 4 | 10 |

This collection of data given in a convincing way the detrimental effect of the poisoning on the off-

spring. The first horizontal line gives the results of fifty-three matings made between alcoholic males and normal females. This is the crucial test of the influence on the germ cell. In twenty-two cases negative results or early abortions followed, while control matings invariably gave offspring. Seven still-born litters consisting of thirteen individuals were produced, while twenty-four, or less than half of the matings resulted in living litters consisting of fifty-one individuals, twenty of which died soon after birth and thirty-one survived. Thus from fifty-three matings only thirty-one surviving young resulted, while the fifth horizontal line shows that thirty-three control matings kept in the same breeding conditions produced fifty-six surviving offspring.

The second horizontal line shows that fourteen matings between normal males and alcoholic females gave little if any worse results than those above, although in this case there are two chances of affecting the offspring, either through the injured egg cell or by the abnormal environment in which the embryo was developed. (Nicloux has shown that alcohol passes directly from the blood of the mother into the blood and tissues of the fetus.) When both parents are alcoholic the results are more pronounced; twenty-seven such matings gave negative results or early abortions in more than half of the cases, and only little more than one-third of the matings gave living litters. The twenty-seven matings produced only nine surviving offspring against fifty-six offspring from thirty-three control matings; the difference is decisive.

A summary of the results of the matings between alcoholic guinea pigs may be expressed as follows: in a total of ninety-four matings thirty-eight, or more than forty per cent., were negative or resulted in early abortions, while thirty-three control matings never failed to give full-term offspring. Of the fifty-six alcoholic matings which gave litters reaching term, thirteen or twenty-three per cent. were still-born litters while forty-three were living litters consisting of eighty-four individuals, forty per cent. of which died within a few days.

The thirty-three control matings gave rise to only one still-born litter. In thirty-two living litters of sixty individuals only four young, or six per cent., died. The results of these matings stand in striking contrast to those of the alcoholized animals.

The three lower lines of the table give the data obtained from the few combinations made up to that time with the offspring of the treated animals. These animals are termed second generation and have not themselves been treated. When they are mated with normal animals the results are perfect, as if the healthy individual could counteract any weakened condition present in the other animal.

Second generation guinea pigs mated with alcoholic animals gave in the two cases still-born litters consisting of five fetuses, one of which was deformed. It must be remembered that in the twenty-seven matings made between animals both of which were alcoholic, only three still-born litters occurred.

The matings between two second generation animals showed that they were not so vigorous as the control, and in some cases their young were very defective. One offspring from these animals was completely eyeless, no traces of optic vesicles seem to have arisen. I have been able to produce monsters of this type by weakening the development of fish and chicken embryos.

Very striking experiments showing the production of pathological embryos from injured eggs or spermatozoa have been contributed by Oscar Hertwig. The unfertilized eggs of the frog have been subjected to the action of radium emanations for different periods of time and subsequently fertilized by normal spermatozoa. Eggs treated for several hours gave rise to embryos showing various pathological conditions which Hertwig believes fall into a common type. The same result is obtained if the spermatozoa be treated with radium and then used to fertilize normal eggs. When both the eggs and spermatozoa are treated the pathological conditions exhibited by the embryo are still more pronounced.

Careful cytological study showed that the chromatin of the egg and sperm nuclei was the material most affected by the action of the radium. The following evidence seems to show that it is the deranged chromatin which causes the resulting pathological conditions.

When eggs were treated for very long periods with radium and then fertilized by normal spermatozoa, normal embryos resulted. This peculiar result is due to the fact that the long radium exposure entirely disorganized the chromatin of the egg nucleus so that it no longer takes part in development and the normal sperm nucleus enters the egg and causes development to take place in a proper manner. This phenomenon of development of an enucleated egg fertilized by a normal sperm is termed merogony, and was first recorded by the German cytologist, Boveri, about twenty years ago.

Hertwig also found that when the spermatozoa were treated beyond certain periods and then used to fertilize normal eggs, the egg no longer developed pathologically but normally. This is explained as due to the sperm having suffered the death of its chromatin but still being able to penetrate the egg it stimulated development as a parthenogenetic agent.

These experiments all show that the pathological condition of the embryos may sometimes be due to the defective nature of the germ cells from which they arose. This cause of pathological structures is not, however, so frequently encountered as that of environmental influences on development which may now be considered.

*Environmental Influences.*—Diseased and abnormal environments are responsible for the great majority of pathological embryos. Although the egg is normal and begins a normal development, a change in the environment or the administration of any poison will modify the course of development and cause pathological conditions.

Fishes' eggs may be allowed to develop normally through several stages and may then be subjected to small doses of alcohol, ether, chloroform, magnesium, etc., which will change the course of development in rather definite ways. By these methods I succeeded in causing more than fifty per cent. of normal eggs to give rise to cyclopean monsters. The embryos possessed a median eye and other more or less modified structures, though they were able to hatch and swim about. Such experiments conclusively prove that many types of monsters may arise from perfectly normal eggs developing in an unfavorable environment.

Mall's data on tubal pregnancies are strong evidence in point. It was found that ninety-six per cent. of the embryos obtained from tubal pregnancies were pathological, while only seven per cent. of the uterine pregnancies contained abnormal embryos. The tube is unfitted as a site for normal placentation, the embryo is poorly nourished and probably injured by inflammatory products. The effects of a diseased uterine wall are well shown; the embryos either develop in a stunted, poorly nourished condition, or are incapable of survival and are aborted. In almost all of these abortions the chorion is found to be diseased. Mall has studied this point more thoroughly than other observers, and states that "It appears now that the membranes of nearly all pathological ova are pathological, and, what is more, the decidua, syncytium, and chorion are frequently affected in specimens containing apparently normal embryos. . . . . More recent investigations of this question show that the chorion is diseased in 113 out of 132 pathological specimens studied. The nineteen

in which the chorion is said to be normal show changes in the decidua in a few cases. Fifteen of them are ova without embryos, that is, specimens in which the embryonic mass was destroyed at a very early date. In some of these the chorion and decidua are undoubtedly normal in every respect."

Mall concludes that, "one point is certain, disease of the chorion is as common as are pathological embryos, and the two usually coincide."

The amnion is often diseased and the hydramnios and oligohydramnios conditions are met in various stages of pregnancy. Amniotic adhesions also occur, but their importance in the production of monstrosities has doubtless been much exaggerated. These adhesions are rarely, if ever, observed in studying early embryos. It must be remembered that almost all types of monsters which have been observed among the amniota are also found in the lower vertebrates, fishes and amphibians, where the amnion is not present.

The generally inflamed condition of the uterus which is observed in connection with many aborted embryos as well as the time at which these abortions most frequently occur, suggest a connection with the tendency of the menstrual rhythm to persist after pregnancy has begun. The largest number of pathological embryos are formed during the first seven weeks of pregnancy and very few occur after the tenth week. During this time the embryos are in the most susceptible stage for gross developmental changes to occur. After the tenth week the primary organs are formed and their development is underway, so that it is difficult to disturb their courses without killing the embryo entirely.

At a time during the first few weeks of pregnancy the regular menstrual period arrives and the periodic impulse is so firmly developed in certain individuals that the uterine wall responds to a greater or less extent. It frequently happens at this time that the very young ovum is passed out and lost, often without the knowledge of the parent. I may suggest as a speculation that when the impulse is not so pronounced, it may still be of sufficient importance to injure the embryonic membranes, affect their implantation, and thus indirectly modify the developing embryo. Such an embryo may later be aborted as a pathological specimen.

The menstrual impulses are successively weaker and if the embryo successfully survives the second it no doubt continues development more or less undisturbed. The sudden cessation of the rhythmical menstruation following pregnancy is not always complete and the influence of the first few suppressed attempts at menstruation on the part of the uterine wall may be a much more important factor in the causation of pathological embryos than has been recognized.

Improper adjustment or relationship between ovulation and menstruation may be the possible cause of faulty implantation in many cases. The uterine wall is not in a favorable physiological state at the time the ovum is received. This may be the explanation of at least some cases of sterility.

The condition of the maternal ovary in cases of pathological embryos needs careful investigation. Experiments by L. Loeb seem to show that the proper development of the decidua depends upon the presence of a normal corpus luteum. The failure of the corpus luteum to form may give rise to cystic conditions with no luteum "secretion" and in such instances the ovum does not become properly implanted and either pathological embryos or abortions may result.

Developmental Stages at Which Abnormalities Occur.—The types of pathological embryos depend really more decidedly upon the stage of development at which the injurious stimulus acts than upon the nature of the stimulus. Most of the gross deformities, such as double monsters, double heads, spina bifida, accessory limbs, cyclopia, etc., originate only during early embryonic stages, and after development has progressed beyond these stages their production is impossible. An unfavorable environment is, therefore, much more injurious on early than on late developmental stages, and the action of a number of entirely different substances applied at similar stages may often result in the same type of deformity.

If the same substance is applied at successive stages of development quite different responses result; when fishes' eggs in early stages of development are placed in certain-strength solutions of sodium chloride, they are fatally injured and develop for a short time only; when, however, the same eggs are allowed to develop to later stages, they may then be put into sodium chloride solutions of three times the strength without being seriously injured in the type of their development, and they may live for days or weeks in the solution.

The eggs of the fish in early stages placed in certain solutions of KCl will, as Loeb recorded, develop and live for weeks although the heart does not beat and the blood, of course, does not circulate. If these eggs be allowed to develop normally until the heart beat has been established, KCl solutions are fatal within a very short time as the heart is stopped and death follows. Thus if an embryo has never established a circulation it may live and continue its development in a somewhat modified fashion for a long time, though if the circulation has once begun its arrest results in the prompt death of the embryo.

The developing individual, therefore, responds to the same stimuli in a different manner at almost every stage in its development. Alcohol and a number of other substances, when administered to early embryonic stages of the fish or chicken and probably also to mammals, causes gross abnormalities in the structure of the brain and optic vesicles. The same substances acting on later stages produce only minor abnormalities, and still later they fail to cause any noticeable structural change; yet there is such a change as is indicated by the deranged nervous responses shown by the embryos after they have hatched. When certain doses of the substances are given to very young offspring they may be fatally injured by the effects upon the nervous system, while adults of the same species might readily stand even larger doses with minor temporary effects. The acute susceptibility of early developmental stages to almost all types of chemical stimuli should be strongly emphasized, since the use of various drugs in attempting to produce abortion during the early stages of pregnancy may fail to produce the abortion and yet derange the development of the embryo to such an extent as to cause it to develop into a monster individual.

Disease of the mother has an effect upon the early embryo not by causing it to experience the same disease, but by weakening or arresting its development in certain ways.

Developmental Arrests.—A surprisingly great number of pathological forms and often the grossest deformities are, when more thoroughly understood, types of developmental arrests. Again, the nature of the deformity depends primarily upon the developmental stage at which the arrest occurred or began. Many of the responses on the part of embryos to certain forms of chemical treatment have been considered as specific for the substance used; Herbst's "lithium larvæ" of the sea urchin, and my "magnesium embryo" of the fish, are cases in point. By further and more extensive investigations of the subject it was found that alcohol, chloroform, ether, manganese, etc. might cause the same defects as mangesium had produced, and, still more recently,

I have been able to class most of the deformities induced by chemical treatments as developmental arrests. The results are closely similar to those conditions which occur in the development of embryos within weak and diseased mothers. Poor placentation with lowered metabolism on the part of the embryo is sufficient in itself to cause a great variety of structural defects apparently of the most varied types, yet on thorough analysis they all prove to be of the nature of developmental arrests.

On account of the importance of these arrests and to make the meaning somewhat clearer, it may be well to consider briefly the analysis of a concrete case. The defect known as cyclopia or synophthalmia has been recorded since ancient times and numerous speculations have been advanced as to its cause. It was long thought to be due to germinal origin or changed germ cells, and even recently H. H. Wilder has attempted to defend such a position. Experimental evidence, however, has completely demonstrated the error of this view.

The study of a number of cyclopean monsters led several observers to believe that the defect resulted from the fusion of the two eyes in a median plane during development. When the fusion occurred during early stages the two components united in a rather more perfect manner to form a typical median eye; if the fusion occurred later it was more or less incomplete and the double nature of the median eye was evident. This view was generally held by teratologists.

Spemann, by a very clever mechanical experiment, produced double-headed monsters with Triton embryos, and in many cases one of the heads was cyclopean. A study of a number of these heads showed that the cyclopean eye arose from the medullary tube in its final condition and no fusion occurred between eyes that had already arisen. I was able to confirm this conclusion by a study of a great number of cyclopean monsters which were produced by treating fish eggs with several chemical substances.

W. H. Lewis and Spemann have since suggested that the cyclopean defect results from a fusion of the lateral anlagen of the optic vesicles within the medullary tube on account of a failure of median material to arise between these optic anlagen. Although Spemann has shown that no fusion occurred after the eyes arose, he now advocates an earlier fusion after the failure of median material to form. This view is as incorrect as was the older fusion hypothesis. In the first place, cyclopea is an *eye* defect and not a failure of non-ophthalmic material. The eye is often very small and defective and the condition carried further will in many cases entirely suppress the eye formation. In the second place, there is *no* median material between the early eye anlagen. The eye anlage itself is median in position in the early medullary plate and as development proceeds the anlage widens laterally, two growth centers are established, and these push out from a ventrolateral position to form the optic vesicles. These facts I have established by cutting out definite areas from the early medullary plate of salamander embryos.

Since the eye anlage is primarily median and developmental energy is necessary for it to expand laterally and give rise to lateral eyes, one is justified in considering the cyclopean eye as the result of an arrest which does not permit the lateral widening or the establishment of the two growth centers. The various extents of this arrest account for the different degrees of the cyclopean defect.

The widely different methods by which cyclopea may be artificially brought about in different animal forms—pricking the anterior end of the medullary plate in fish embryos, tying the egg of the amphibian so as to produce double-headed monsters with one head small and weakly developed, the treatment of fish and bird embryos with almost any chemical agent which inhibits or arrests the developmental rate and vigor, show the defect to be of a general rather than specific nature.

Thus the cyclopean eye which at first thought would not be interpreted as an arrest is proved to be such by a long series of analytical experiments. Many other defects are known to be of the same nature of origin and many more will probably be added to this class when they are subjected to careful experimental study.

The numerous investigations in experimental teratology and the observations on tubal pregnancies have supplied a mass of evidence to show that the pathological conditions observed in embryos are almost always to be interpreted as the results of unfavorable developmental environments. The pathology of the embryo is thus a subject which readily lends itself to an experimental analysis and its thorough investigation will doubtless reveal important and much needed facts for a more thorough understanding of postnatal pathological conditions. The life of the individual begins at fertilization. Birth is only a change from one mode of existence to another, and should not be allowed to interrupt and divide investigations which properly include the entire history of the individual, rather than its finished stages.

CHARLES R. STOCKARD.

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**Embryology.**—The general history of the embryo is given under *Fetus, Development of*. The development of special organs is treated under those organs; *e.g.* for the development of the brain see under *Brain*. There are also included in the HANDBOOK the following special embryological articles: *Allantois, Amnion, Area Embryonalis, Blastoderm, Blastopore, Chorion, Cœlom, Differentiation, Gastrula, Germ Layers, Impregnation, Neurenteric Canal, Notochord, Placenta, Proamnion, Segmentation of the Body, Segmentation of the Ovum, Umbilical Cord*, and *Yolk Sac*.

In this article are given (1) a brief sketch of the history of embryology; (2) practical directions for the study of embryos.

1. HISTORY OF EMBRYOLOGY.—Although embryology is the department of morphological science now most in vogue among investigators, it has held this high rank but a very short time. Embryology may date its birth, after gestating for many centuries in the womb of science, from the year 1600, when Fabricius ab Aquapendente published his work, "De Formato Fœtu," followed four years later by his "De Formatione Fœtus." After Fabricius came a series of anatomists, who during the seventeenth and eighteenth centuries slowly added to the knowledge of the development of man and other vertebrates; but it was a time of vague general notions, a period when principles which seem to us elementary were still under debate. It was not until Caspar Friedrich Wolff published his dissertation, "Theoria Generationis" (1759), that the mere idea of development by gradual differentiation of unformed material could make its way. Wolff is justly regarded as the initiator of modern embryology, for until his views of gradual differentiation (epigenesis) were established correct embryological conceptions were impossible. The next great advance was due to the influence of Döllinger, of Würzburg, a man who inspired many of the best researches. Under him were trained Pander and von Baer, who first definitely ascertained the existence

and traced much of the history of the germ layers. Von Baer was a magnificent intellect—among the great morphologists of Germany easily first. His book (1829) on the development of animals has never been equalled for keen insight and original profound thoughts in the domain of morphology. The author is no less remarkable for his observational powers. Kölliker says, with perfect truth, that von Baer's researches "are to be described as unconditionally the best which the embryological literature of all time and all peoples has to show." The third epoch may be said to have begun with the establishment of the cell doctrine by Schleiden and Schwann (1839), after which began the labor of ascertaining the origin and metamorphoses of the cells in the embryo. Schwann's discovery led to the recognition of the real signification of the segmentation of the yolk, which had been previously discovered. The next great change occurred during 1860–1870, after Darwin had given a mighty impulse to biology by the publication of his "Origin of Species"; in this period the germ layers were discovered and described in invertebrates by Kowalewsky, Metchnikoff, and others, and in the course of a few years it was definitely proved that the germinal layers exist in all multicellular animals. Since 1870 a multitude of researches have been carried out, a wealth of new discoveries made, largely in consequence of the vast improvements in the methods of investigation. These improvements have been—first, in regard to the means of preserving ova and embryos; second, in the manners of making sections and staining them.

Of recent writers the student of human embryology must place His and Kölliker first; the former has worked out the anatomy of very young human embryos with surprising skill, and the latter has contributed a vast series of observations on the development of nearly every organ and tissue. His's researches demonstrated that the anatomy of the adult is fixed by the fundamental relations in the embryo. He created the science of anatomical embryology, which has since then progressed in America especially. His became, through his investigations on the development of the brain, the founder of modern neurology.

In the history of embryology, then, the following points mark the chief epochs:

1759.—The doctrine of gradual development, or epigenesis, definitely established by Caspar Fr. Wolff.

1829.—The existence of the germ layers demonstrated, and their most important metamorphoses in vertebrates traced out by Carl Ernst von Baer.

1839.—The cell doctrine applied to animals by Schwann, and embryology turned into the study of histogenesis.

1860–70.—The presence of germ layers in invertebrates proven by Kowalewsky, Metchnikoff, and others.

1870–85.—Constantly increasing number of special researches, and steady perfecting of methods.

The principal authorities on Embryology are Kölliker's Entwickelungsgeschichte, 1879; Balfour's Comparative Embryology, 1885; Minot's Human Embryology, 1892; Hertwig's Handbuch der Entwickelungsgeschichte der Wirbelthiere, 3 vols., the most comprehensive work heretofore published; and Keibel-Mall Human Embryology, 2 vols., an indispensable work written by numerous American and German contributors and published in 1912.

2. Embryological Methods.—The student of human embryology cannot obtain his material at will, but can only take advantage of opportunity. A considerable number of abortions and miscarriages, natural and procured, occur in every community, and the ova and embryos thus discharged are, in a minority of cases, normal and fresh; the older the embryo the more likely it is to be in good condition. Embryos less than two inches long are best preserved intact; larger embryos are much better opened, and the parts severed and hardened separately. If the specimen is intended only for the study of gross anatomy, it will suffice to preserve it in seventy per cent. alcohol, which must, however, be renewed once or twice at first, and the larger the specimen the more necessary is the caution of changing the alcohol.

If the specimen is good enough to be used for section cutting, it must be preserved with more care. Embryos of more than seventy days should be opened and partially dissected if good preservation of the internal parts is desired. (*a*) The best single method for the preservation of mammalian embryos is probably Bouin's. The fluid used is prepared by adding to 225 c.c. of a saturated aqueous solution of picric acid, first 75 c.c. formaline, second 15 c.c. glacial acetic acid. Specimens are kept in the fluid from two to seven days according to their size, then transferred to thirty per cent. alcohol for one hour, to fifty per cent. for from one to two hours, to sixty per cent. for twelve hours and finally to seventy per cent. alcohol, which must be changed daily until it no longer shows even a trace of yellow discoloration by picric acid. (*b*) For general use Parker's fluid (formalin 16 c.c., water 784 c.c., and ninety six per cent. alcohol 1,200 c.c.) may be recommended, as it has great penetrating power; it should be renewed after twenty-four and forty-eight hours, and the quantity of fluid should be about ten times the volume of the embryo. (*c*) For embryos of nine weeks or less preservation intact in Zenker's fluid (corrosive sublimate 10 grams, potassium bichromate 5 grams, sodium bisulphate 2 grams, water 200 c.c., glacial acetic acid 10 c.c.) or in von Rath's fluid (saturated solution of picric acid 100 parts, hot saturated solution of corrosive sublimate 100 parts, acetic acid 1 part) may be recommended. Zenker's fluid requires from twelve to thirty-six hours, von Rath's from one-half to two hours, according to the size of the specimen. Both of these require to be followed by treatment with tincture of iodine to remove the corrosive sublimate. (*d*) Of all good methods the most expeditious is to place the embryo or organ for five minutes or less in a mixture of 10 parts strong nitric acid and 90 parts water; transfer to sixty per cent. alcohol for an hour or two, and then to seventy per cent. (*e*) The simplest method of all is to put the specimen into sixty per cent. alcohol for twenty-four hours, then permanently in seventy to eighty per cent. alcohol.

In preserving embryological material observe the following rules: Handle the specimen as little as possible; do not on any account put it in water or wash it; if it is necessary to keep it moist, wrap a soft damp cloth gently round it; never put a fresh specimen in strong alcohol; never keep a specimen in strong alcohol, *i.e.* over eighty per cent. The only time when strong alcohol can be safely used is after a specimen has been hardened; and then only to act for twenty-four hours immediately before embedding.

Charles Sedgwick Minot.

END OF VOLUME III.

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